DOT HS-805 031

IMPROVED HYBRID COMPUTER VEHICLE HANDLING PROGRAM

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Contract No. DOT AS-20029
Contract Amt. $123,000

OCTOBER 1978
FINAL REPORT

Prepared For
U.S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
Washington, D.C. 20590

Technical Report Documentation Page

1. Report No. DOT HS 805 031	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle IMPROVED HYBRID COMPUTER VEHICLE HANDLING PROGRAM		5. Report Date October 1978
		6. Performing Organization Code
7. Author(s) P. F. Bohn and R. J. Keenan		8. Performing Organization Report No. APL/JHU CP 049A
9. Performing Organization Name and Address The Johns Hopkins University Applied Physics Laboratory Johns Hopkins Road Laurel, Maryland 20810		10. Work Unit No. (TRAIS)
		11. Contract or Grant No. DOT-AS-20029
12. Sponsoring Agency Name and Address U. S. Department of Transportation National Highway Traffic Safety Admin. Washington, D. C. 20591		13. Type of Report and Period Covered Final 7/76 - 10/78
		14. Sponsoring Agency Code NHTSA
15. Supplementary Notes		

16. Abstract

The Improved Hybrid Computer Vehicle Handling Program (IHVHP) is an extension of the Hybrid Computer Handling Program (HVHP) described in DOT-HS-802-059, Jul 1976. The computing tasks have been redistributed between the analog and digital computers. Many of the simplifications that existed in the HVHP have been removed. The equations of motion for the sprung and unsprung masses of a vehicle have been expanded to include higher order terms and large pitch and roll angles. Numerous geometric and kinematic calculations have been modified to include large pitch and roll angles. The hybrid computer simulation for vehicle handling studies has been in use for 6 years and can simulate (a) independent front and rear axles, (b) independent front with solid rear axle, (c) independent front and solid rear axle with dual rear tires, (d) solid front and rear axles, and (e) solid front and rear axles with dual rear tires. For validation purposes, braking, steering, and combinations of braking and steering were put into the simulated mathematical model; the simulation time histories were then compared to fullscale test data. The hybrid vehicle handling program can be used for general studies of vehicle dynamics. Performance of the National Highway Traffic Safety Administration (NHTSA) standard passenger car Vehicle Handling Test Procedures (VHTP's) and calculation of the associated performance comparison variables (PCV's) are simulation options. A special interactive user's interface allows program use by vehicle engineers as well as by computer specialists.

17. Key Words Hybrid Computer, Simulation, Vehicle Mechanics, Limit Performance Test Procedures, Vehicle Handling, Comparison Variables	18. Distribution Statement Document is available through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report) UNC	20. Security Classif. (of this page) UNC	21. No. of Pages 388	22. Price

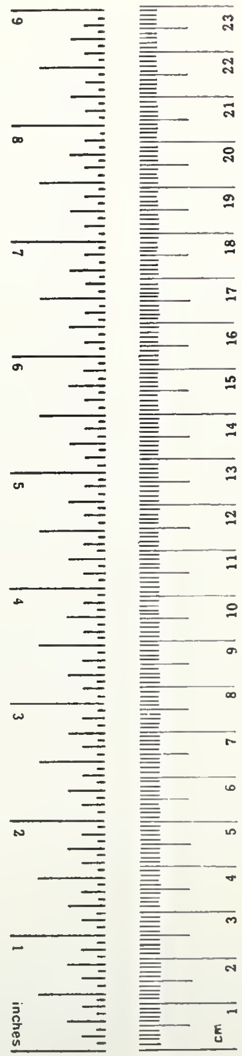
Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

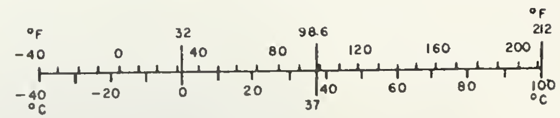
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



ABSTRACT

The Improved Hybrid Computer Vehicle Handling Program (IHVHP) is an extension of the Hybrid Computer Handling Program (HVHP) described in DOT-HS-802-059, Jul 1976. The computing tasks have been redistributed between the analog and digital computers. Many of the simplifications that existed in the HVHP have been removed. The equations of motion for the sprung and unsprung masses of a vehicle have been expanded to include higher order terms and large pitch and roll angles. Numerous geometric and kinematic calculations have been modified to include large pitch and roll angles.

The hybrid computer simulation for vehicle handling studies has been in use for 6 years and has been validated for a large class of two-axle vehicles. The following suspensions can be simulated: (a) independent front and rear axles, (b) independent front with solid rear axle, (c) independent front and solid rear axle with dual rear tires, (d) solid front and rear axles, and (e) solid front and rear axles with dual rear tires.

For validation purposes, braking, steering, and combinations of braking and steering were put into the simulated mathematical model, and the simulation time histories were then compared to full-scale test data.

The hybrid vehicle handling program can be used for general studies of vehicle dynamics. Performance of the National Highway Traffic Safety Administration (NHTSA) standard passenger car Vehicle Handling Test Procedures (VHTP's) and calculation of the associated performance comparison variables (PCV's) are simulation options. A special interactive user's interface is available to allow program use by vehicle engineers as well as by computer specialists.

CONTENTS

ILLUSTRATIONS

Section 1

SUMMARY AND INTRODUCTION

1.1 SUMMARY

This document presents the latest version of the National Highway Traffic Safety Administration (NHTSA) Improved Hybrid Computer Vehicle Handling Program (IHVHP), which is operational at the Applied Physics Laboratory of The Johns Hopkins University (APL/JHU). The IHVHP evolved from the Hybrid Computer Vehicle Handling Program (HVHP), which is described in Ref. 1. Many refinements have been incorporated into the current simulation, the major changes being that (a) the equations of motion for the sprung and unsprung masses of a vehicle have been expanded to include higher order terms and large pitch and roll angles and (b) numerous geometric and kinematic calculations have been modified.

1.2 INTRODUCTION

APL first became involved in the prediction of vehicle dynamic performance via simulation in May 1972. At that time, NHTSA requested APL to move an existing vehicle simulation operational on the hybrid computer from the Bendix Research Laboratories (BRL) to APL (Refs. 2 and 3). NHTSA's reason for moving the simulation was to make it available to all NHTSA contractors for vehicle

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Ref. 1. P. F. Bohn and R. J. Keenan, Hybrid Computer Vehicle Handling Program — Second Edition, DOT-HS-802-059, Applied Physics Laboratory, The Johns Hopkins University, July 1976.

Ref. 2. Vehicle Handling, Final Report, Vol. II, Technical Report, DOT HS-800-282, Bendix Research Laboratories, Southfield, Michigan, April 1970.

Ref. 3. Computer Simulation of Vehicle Handling, DOT HS-800-789, NHTSA Control FH-11-7563, Bendix Research Laboratories, Southfield, Michigan, September 1972.

research. APL reprogrammed the BRL simulation for its hybrid computer without changing the model; the result was published in Ref. 4. The derivation of the original HVHP model is presented in Ref. 5.

Work with NHTSA contractors began in July 1973, when APL started providing simulation service to the Calspan Corporation on the NHTSA research on the effects of tire properties on vehicle handling (Ref. 6). During the work with Calspan, two primary simulation modifications were completed by APL:

- A very flexible user interface for interactive simulation control designed at APL was added, and

- A new tire force and moment model specified by Calspan was added.

Also added to the simulation about this time was the capability automatically to initialize the simulation to perform any of the six Vehicle Handling Test Procedures (VHTP's) and to collect and process the data required to calculate the vehicle performance comparison variables (PCV's). These VHTP's and PCV's were originally developed by the Highway Safety Research Institute (HSRI), University of Michigan (Refs. 7 and 8) and restated for computer

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Ref. 4. P. F. Bohn, R. J. Keenan, and J. Prowznik, Operational Hybrid Computer Simulation for Vehicle Handling Studies, DOT HS-800-764, Applied Physics Laboratory, The Johns Hopkins University, September 1972.

Ref. 5. F. Jindra, Mathematical Model of Four-Wheel Vehicle for Hybrid Computer Vehicle Handling Program, DOT HS-801-800, Ultrasystems, Inc., The Dynamic Science Division, October 1975.

Ref. 6. Research on the Influence of Tire Properties on Vehicle Handling, Final Report, Contract DOT HS-053-3-727, Calspan Corporation, June 1974.

Ref. 7. R. D. Ervin, P. Grote, P. S. Fancher, C. C. MacAdam, and L. Segel, Vehicle Handling Performance, DOT HS-800-758, Highway Safety Research Institute, University of Michigan, November 1972.

Ref. 8. P. S. Fancher, R. D. Ervin, P. Grote, C. C. MacAdam, and L. Segel, Limit Handling Performance as Influenced by Degradation of Steering and Suspension, DOT HS-800-761, Highway Safety Research Institute, University of Michigan, November 1972.

implementation by APL (Ref. 9). The result of this work was the HVHP documented in Ref. 10.

The computer program was further extended in 1974 by the Dynamic Science Division of Ultrasystems, Inc., to simulate features of recreational vehicles (Ref. 11). These features included aerodynamic effects, solid front axle, dual rear wheels, and four-wheel drive.

The HVHP model equations describing tire-road reaction moments about the kingpin axis were modified during a recent roadway disturbance study conducted by Systems Technology, Inc. (Ref. 12). The change was required to account for the effect of the tilt of the tire contact patch with respect to the horizontal plane.

These program modifications have been implemented and verified with full-scale vehicle test results. Currently, dynamic performance of vehicles of the following suspension types can be predicted by the IHVHP:

- Independent front and rear suspensions
- Independent front with solid rear axle
- Independent front and solid rear axle with dual rear tires
- Solid front and rear axles
- Solid front and rear axles with dual rear tires

Ref. 9. P. F. Bohn, "Modeling and Simulation in Vehicle Handling," DOT HS-82-306, Vehicle Safety Research Integration Symposium, Applied Physics Laboratory, The Johns Hopkins University, 30 May 1973.

Ref. 10. P. F. Bohn and R. J. Keenan, Hybrid Computer Vehicle Handling Program, DOT HS-801-290, Applied Physics Laboratory, The Johns Hopkins University, July 1974.

Ref. 11. Handling Test Procedures for Light Trucks, Vans, and Recreational Vehicles, Final Report, DOT HS-801-824, Ultrasystems, Inc., The Dynamic Science Division, February 1976.

Ref. 12. Influence of Roadway Disturbances on Vehicle Handling, Final Report, DOT HS-802-210, Systems Technology, Inc., February 1977.

Validation of each suspension type has been accomplished by comparison of simulation and full-scale test data.

In its work with NHTSA contractors, APL has added to the simulation model any refinements required by a contractor to complete his research successfully; the simulation has proven to be economical for vehicle dynamic performance prediction. User experience with the IHVHP has shown that, while performing parametric runs, 500 s of vehicle motion can be simulated in 1 h of computer use. This translates to a cost of less than $0.50/s of simulated motion and represents a 50% utilization of the available computing time. Since this simulation, running at one-fourth real time, is capable of 900 s of simulated motion per hour, approximately 50% of the time is utilized for observing data and changing parameters. The $0.50/s should be viewed as the current lower cost limit.

For program debugging and model checkout, fewer runs are made in a given time period than when parametric data are being produced. Therefore, the cost per second of simulated motion would increase. However, general experience has indicated that on-line data observation for debugging decreases the total time required for program checkout. During the debug phase, IHVHP cost usually ranges between $1.00 and $2.00/s of simulated motion, with a decreasing trend toward the $0.50/s cost.

Section 2

IMPROVED HYBRID COMPUTER VEHICLE HANDLING PROGRAM

2.1 INTRODUCTION

This section describes the Improved Hybrid Computer Vehicle Handling Program (IHVHP). The basic mathematical model, contained in Appendix A, is described in terms of 17 degrees of freedom (DOF). The perturbing forces and moments that act on the vehicle are also considered. The simulation implementation and validation are discussed.

2.2 SIMULATION

2.2.1 Mathematical Model

The simulated vehicle is represented by a 17-DOF model that consists of

- A basic 6-DOF model of the vehicle sprung mass
- A 2-DOF front wheel or front axle model
- A 2-DOF rear wheel or rear axle model
- A 3-DOF steering system model
- A 4-DOF wheel rotational dynamics model

The 6 DOF's of the sprung mass model are the 6 standard translational and rotational DOF's of a body moving in inertial space: translation along three axes and rotation about each axis. The 2 front wheel DOF's represent the motion of the front unsprung masses. For an independent front suspension, the 2 DOF's are the vertical motion of each front wheel. If the front suspension represents a solid axle configuration, the 2 DOF's are the rotation and vertical motion of the front axle. The 2 rear wheel DOF's are analogous. An analytical representation of the vehicle model showing independent front and solid rear axle suspensions is illustrated in Fig. 2-1. A solid rear axle representation is presented in Fig. 2-2.

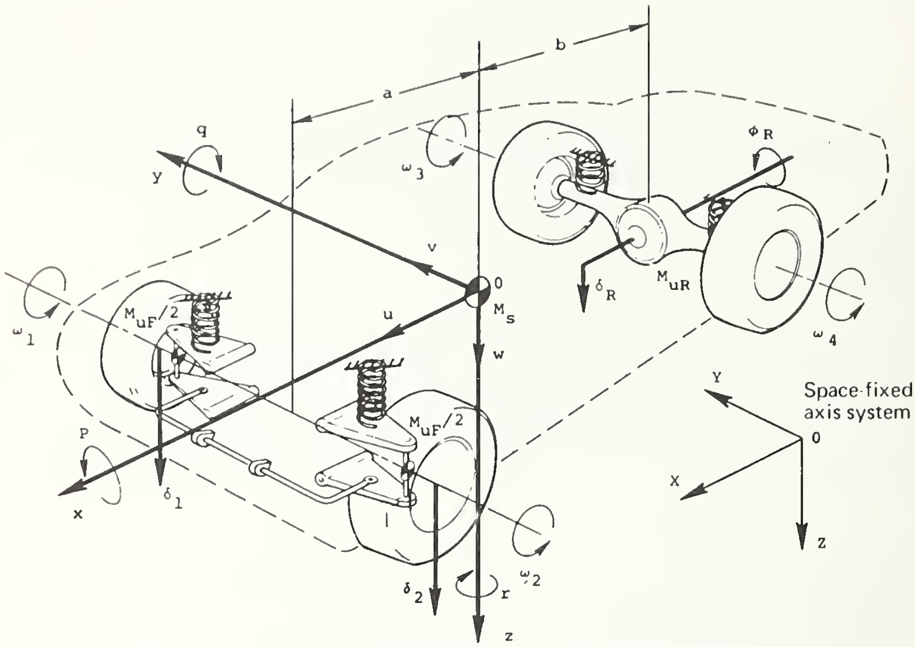

Fig. 2-1 Analytical Representation of the Vehicle Model

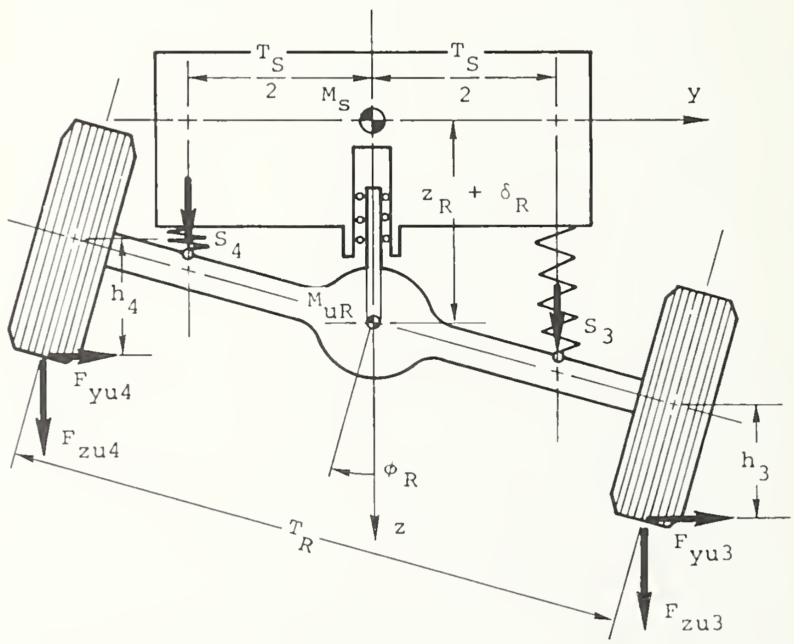

Fig. 2-2 Analytical Representation of the Solid Rear Axle Model

The vehicle model allows the following options:

- Independent rear suspension (two rear unsprung masses) with 2 DOF's corresponding to the vertical motion of each rear wheel,

- Solid front axle (front unsprung mass) with 2 DOF's corresponding to the vertical motion and rotation of the front axle, and

- Dual tires on a solid rear axle with either independent front suspension or solid front axle.

Inertial coupling between the sprung mass and the front and rear unsprung masses is considered, but external forces and moments due to rolling resistance and gyroscopic effects of the rotating parts are neglected.

The steering system is represented by a lumped parameter model with 3 DOF's corresponding to the rotational motion of each front wheel about its steering pivot and translational motion of the connecting steering rod and associated mass elements. The effects of steering system friction and compliance are included. The tire moments about each kingpin axis are functions of the circumferential and side tire forces, tire aligning torque, the inclination and caster of the kingpins, and the caster trail effects of the tires. Steering wheel displacement is the steering system input.

Four additional DOF's (for the total of 17) are contained in the rotational equations of motion about the spin axis of each wheel. These equations, which include the differential effects of the front or rear wheels, yield the wheel rotation rates from which slip and, in turn, the circumferential and lateral friction coefficients are computed. The differential equations for wheel rotation are assumed to be isolated from the coupled differential equations of motion of the sprung and unsprung masses, but inertial interaction between the drive wheels is included.

Forces are transmitted between the sprung and unsprung masses through the suspension system. The suspension forces include spring effects, shock absorbers, auxiliary roll stiffness, coulomb friction, and "anti" forces such as antipitch and antiroll. The suspension deflections are calculated relative to the suspension equilibrium position, which varies with vehicle weight. The angular orientation (camber angle, toe angle, caster angle) of an independently suspended wheel relative to the vehicle body is specified as a function of the suspension deflection. These functions

are input relative to the equilibrium vehicle suspension position and then corrected to the new equilibrium position for varying vehicle weight configurations. Compliance coefficients are used to relate the change in camber angle and steer angle with applied forces and moments at the tire. Provisions are also incorporated to investigate the effects of degraded suspension components.

The force of gravity, aerodynamic forces and moments, and tire forces and moments generated at the tire-road interface are considered the only important externally applied forces and moments acting on the vehicle. The tire forces include the normal force arising from radial tire deflection, the side force due to slip angle and inclination angle, and the circumferential force arising from applied torque. Since the roadway is treated as a flat horizontal plane, a "point-contact" representation of the tire is used to obtain the radial loading. The circumferential force calculation uses a two-straight-line approximation of friction coefficient-slip behavior. The side force calculations are based on slip-angle and inclination-angle properties of the tires that are saturated at large angles. Interaction between circumferential and side forces utilizes a modified "friction-ellipse" concept that "rolls off" side force as a function of tire slip. The rolloff characteristic is an empirical relationship obtained from tire test data. The tire-aligning torque and overturning moment are modeled as nonlinear functions of lateral force, normal force, and inclination angle. To account for differences in tire characteristics at the front and rear wheels, provisions are made to input separate parametric sets for front and rear tires.

Open-loop control inputs can be entered in the form of steering wheel angle and drive or brake torque. The drive torque is generated to maintain a constant velocity of the vehicle. The brake torque magnitude is determined from input data functions of brake line pressure at the front and rear wheels. Since the equations of motion are written in terms of a moving vehicle's axis system, a coordinate transformation is required to relate the vehicle's position and orientation with respect to an orthogonal coordinate system fixed in space.

2.2.2 Allocation of Analog and Digital Computer Tasks

Since the model is solved on a hybrid computer, it must be subdivided into equations to be solved on the analog computer and those to be solved on the digital computer. Computing tasks were allocated using the following guidelines:

- Function generation requiring extensive algebraic calculations or references to tables of values should be performed on the digital computer.

- System variables determined from the solution of differential equations should be graded according to response time (time constant). The differential equations representing the fastest variables should be solved on the analog computer and the remaining equations solved on the digital computer.

Slight compromises to the task allocation as determined by the above rules were required due to limitations in digital computer computation speed, numbers of analog computer computation modules, and available analog-to-digital and digital-to-analog data communication modules.

The present allocation of computing tasks between the analog and digital computers is presented in Fig. 2-3. Calculated in the digital portion are the longitudinal wheel slip, circumferential coefficient of friction, wheel orientation angle equations, and tire force equations, as well as wheel brake and drive torques, velocities of the tire contact point, and resultant forces and moments.

The analog computations include the suspension forces, shock absorber and wheel sprung functions, and wheel spin velocities. In addition, the equations of motion of the sprung and unsprung masses and steering system equations are solved on the analog computer.

The hybrid simulation is time scaled to run normally at one-fourth real time, i.e., 20 s of clock-on-the-wall time is required for 5 s of vehicle simulation. However, one-half real-time operation, with subsequent cost savings, is possible.

2.2.3 Implementation of the Mathematical Model

2.2.3.1 Analog Portion. The APL/JHU hybrid computer facility (Appendix B) contains analog machines manufactured by Electronic Associates, Inc. (EAI). The portion of the model programmed on the analog computer is divided between models of EAI analog computers. The entire steering system is contained on an EAI 231-R, and the rotational wheel dynamics, equations of motion, and suspension dynamics are contained on an EAI 680. Data communication with the digital computer is provided by 24 multiplying digital-to-analog converters (MDAC's), 24 nonmultiplying DAC's, and 48 analog-to-digital converters (ADC's). The system contains a control interface

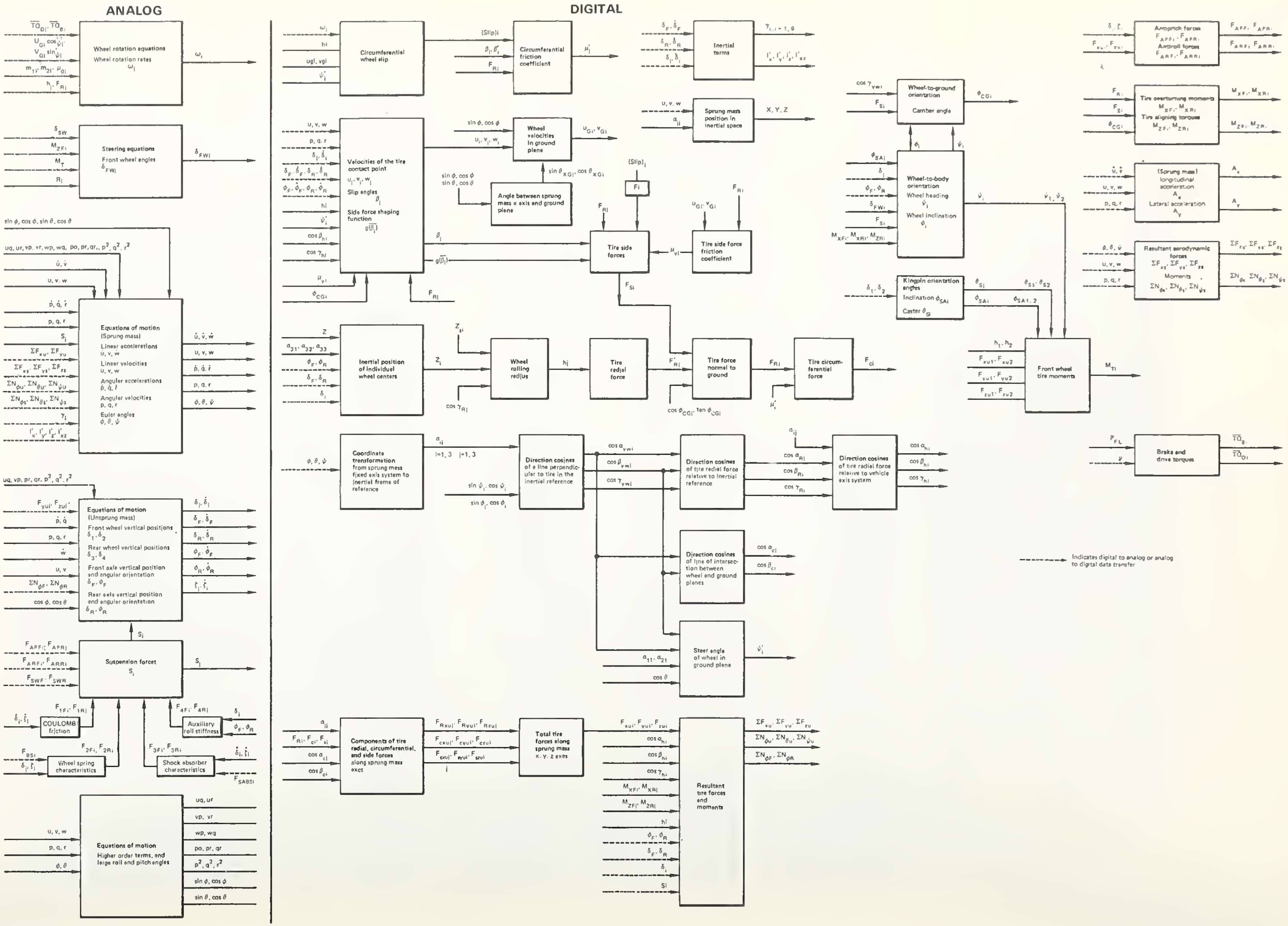

Fig. 2-3 Hybrid Simulation Block Diagram of the IHVHP Model

that allows complete control of the 680 analog computer and data interface by the digital computer.

To expedite setup and checkout of the analog portion, a static analog test program for three suspension configurations was used:

- Independent front and rear
- Independent front with solid rear axle
- Solid front and rear axles

This was accomplished by programming the mathematical model equations solved on the analog computer as a digital simulation language program (Ref. 13). The digital program output provided an independent check of the simulation. The static check results verify that the programmed analog portion of the simulation represented the particular vehicle mathematical model equations.

2.2.3.2 Digital Portion. The APL/JHU hybrid computer facility (Appendix B) uses an IBM 360/91 for digital calculations. Model coding is performed in the Fortran IV language. Model calculations not assigned to the analog computers are performed digitally.

2.3 USER'S INTERFACE

The interface between the engineering user and the computer has been designed to maximize user control and information retrieval from the hybrid computer (Ref. 14). The interface has been implemented by a set of generalized input/output subroutines. Using these communication routines, the following necessary tasks can be accomplished interactively at the CRT hybrid control console:

- Interrogation of any digital variable, including arrays, by name,
- Assignment of new values to any digital parameter or initial condition,

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Ref. 13. P. F. Bohn, "Simulation Language Generated Static Checks for Hybrid and Analog Simulations," Simulation, September 1971.

Ref. 14. K. W. Colby and P. F. Bohn, "Generalized Man/Machine Communication Subroutines for Hybrid Simulation," Proceedings of the Summer Computer Simulation Conference, July 1974.

- Tracking and printing the values of any digital variable as a function of time,

- Printing the end-of-run values of any digital variable or parameter,

- Performing automatically a group of parametric runs varying one or more parameters or initial conditions by an arbitrary amount,

- Assigning new digital variables to the DAC's and ADC's,

- Rescaling the digital variables output on the DAC's or input on the ADC's,

- Notating the computer output with observations pertinent to the computer runs, and

- Printing the value of all digital variables on command.

The usefulness of these routines is augmented by the following features:

- The output unit for all digital computer responses is selectable (line printer, CRT, or both).

- Extensive subroutine error recovery allows operation by untrained personnel.

- Free format input obviates the need to always insert decimal points, spaces, etc., which is required by Fortran syntax.

An explanation of the modules that are the building blocks of the routines, as well as a discussion of interaction, is presented in Appendix C.

2.4 VHTP MANEUVERS AND PERFORMANCE COMPARISON VARIABLES

Due to the importance of handling test procedures in vehicle research, the IHVHP was programmed to perform automatically those test procedures defined for passenger cars (Ref. 9). The associated performance comparison variables (PCV's) for the Vehicle Handling Test Procedures (VHTP's) are also automatically calculated. Since test procedures generally employ the input commands of braking, steering, and combinations of braking and steering, the IHVHP implementation can generally be used to generate test procedures for all

type of vehicles. The PCV's are less general and refer specifically to the National Highway Traffic Safety Administration (NHTSA) passenger vehicle VHTP's defined in Ref. 9.

2.4.1 VHTP Maneuvers

The simulation has the capability of self-initializing to perform any of the six automobile VHTP maneuvers and of calculating the PCV's appropriate for the selected VHTP. Using the communication routines, a VHTP is selected by addressing the Fortran variable VHTPNO and assigning it a value from 1 to 6. The value of 0 is reserved for a special check run that verifies correct dynamic operation of the simulation. Once a VHTP has been selected, the system forcing function pertinent to the VHTP can be accessed. For all VHTP's, the Fortran variable PFL represents brake line pressure. For VHTP's 2 to 6, the steering wheel input has the Fortran name STR2, STR3, etc. The names PFL, STR2, etc. can be used in the multiple-run routine to simulate a series of VHTP tests in which the brake line pressure or steering wheel input is incremented. By convention, when a VHTP is selected in which the steering input is normally a parameter (VHTP 2, 4, or 5), the STR variable contains the steering wheel rotation required to input 2.0° of normalized steer. This value is required for run series in which the steering is incremented.

2.4.2 VHTP Performance Comparison Variables

PCV's are output in both the single-run and multiple-run modes. If a single run is executed, a general comparison variable format is selected in which all PCV's are output. However, only those pertinent to the selected VHTP will be nonzero. If a series of runs is executed, the output is in a tabular format with the forcing function (steering wheel angle or brake line pressure) starting in the left column followed by the pertinent PCV's. An example is presented in Fig. 2-4, in which the following occur:

1. VHTP is selected.

2. The STR4 variable is interrogated to determine the steering wheel rotation for 2° of normalized steer.

3. The steering wheel input is set equal to 300°.

4. A single run is executed.

```
TERMINAL ACTIVE
       HYBRID VEHICLE HANDLING PROGRAM
 HYBRID COMPUTER PROB*  91
CARNEW   LOAD MODULE
DODGE71 VEHICLE


 ENGAGE PATCH PANEL FOR TEST
 TYPE CR WHEN READY
****
MAY        12  1976
TIME  11:15: 0.46
OPTION
****  F
ENTER
****  VHTPNO 4
****
OPTION
****  IC
OPTION
****  F
ENTER
****  STR4
   27.93
****  STR4 300
****
OPTION
****  X
MAY        12  1976
TIME  11:16: 0.94
RUN   1 HAS STARTED
OUTPUT BELOW
 AXAV=   0.0    DECL TIME=   0.000 AVCUR=   0.720 BTDMAX=   0.222 BTMAX=   0.171 DELBT=   0.172
AYMAX=   0.762 PHIMAX=   7.754 RMAX=   0.572 LANE CHNG DEL=   0.0    DELFSI=   0.0   MAX STEER= 300.000
FTRQMAX=         0. RTRQMAX=         0.

OPTION
****  F
ENTER
****  VHTPNO 4
****
OPTION
****  MULTI
NUM OF LOOPS,VARS
****  4 1
VAR
****  STR4
LOOP,VAL,INC
****  1 27.9 27.9
****
OPTION
****  XM
MAY        12  1976
TIME  11:17:24.42
RUN   2 HAS STARTED
OUTPUT BELOW
MULTI TOTAL STR4..(   1) BETAMX(   1) BETDMX(   1) CUVRAT(   1) AYMAX.(   1) RMAX..(   1)
  1     2       27.9        0.363E-02    0.123E-01    0.579E-01    0.754E-01    0.431E-01
  2     3       55.8        0.104E-01    0.331E-01    0.150        0.187        0.114
  3     4       83.7        0.196E-01    0.538E-01    0.247        0.305        0.184
  4     5       112.        0.340L J1    0.761E-01    0.344        0.422        0.256
OPTION
****  TERM
MAY        12  1976
TIME  11:19:11.53
PROGRAM TERMINATED
```

Fig. 2-4 IHVHP User's Interactive Control

5. A run series of four runs is set up with STR4 initialized to 2° normalized steer (NS) and incremented by 2° NS in each run.

6. A multiple run is executed.

7. The program is terminated.

A representative parametric run series for each VHTP is presented in Figs. 2-5 through 2-10. PCV graphs for four vehicles are presented in Appendix D.

2.5 VALIDATION

Through cooperative research efforts with different NHTSA contractors, the Hybrid Computer Vehicle Handling Program (HVHP) has been validated at least once for each type of suspension configuration and many times for the standard American passenger car suspension. In each case, validation consisted of the contractor comparing simulation and full-scale test time history responses. Therefore, in addition to APL validation, the HVHP performance has been examined by engineers with extensive backgrounds in vehicle handling.

The IHVHP evolved from the HVHP. The major improvements and refinements are discussed in Subsection 2.5.1.6. For validation purposes, the IHVHP was exercised for each type of suspension configuration. Comparisons of the IHVHP simulation results (transient and steady-state) with previously obtained HVHP simulation results showed acceptable agreement between the two programs.

2.5.1 NHTSA Research Programs

The following paragraphs summarize the completed NHTSA research programs in which the HVHP and IHVHP were used.

2.5.1.1 Passenger Car Tire Effects Program. The HVHP was used extensively for vehicle simulation while APL worked cooperatively with the Calspan Corporation on DOT contract HS-053-3-727 (Ref. 6). For this contract, "Research on the Influence of Tire Properties on Vehicle Handling," Calspan was responsible for refining the tire/road interface model that APL incorporated into the HVHP. Calspan monitored the simulation modification and examined the output for authenticity.

```
OPTION
****  F
ENTER
****  VHTPNO 1
****
OPTION
****  IC
OPTION
****  MULTI
NUM OF LOOPS,VARS
****  4 1
VAR
****  PFL
LOOP,VAL,INC
****  1 300 100
****
OPTION
****  XM
MAY       10  1976
TIME  10:54:25.90
RUN   7 HAS STARTED
OUTPUT BELOW
MULTI TOTAL PFL...(   1) AXAVE.(   1) TIMDEC(   1) AYMAX.(   1) SLIPI.(   1) SLIPI.(   2) SLIPI.(   3) SLIPI.(   4)
  1     7        300.        -0.417         2.74       0.128E-01    0.890E-01    0.889E-01    0.873E-01    0.869E-01
  2     8        400.        -0.556         2.05       0.110E-01    0.117        0.117        0.119        0.117
  3     9        500.        -0.650         1.76       0.335E-01    0.140        0.148         1.00         1.00
  4    10        600.        -0.654         1.74       0.226E-01     1.00        0.998         1.00         1.00
```

Fig. 2-5   IHVHP Interaction for VHTP 1

```
OPTION
**** F
ENTER
**** VHTPNO 2
****
OPTION
**** IC
OPTION
**** MULTI
NUM OF LOOPS,VARS
**** 4 1
VAR
**** PFL
LOOP,VAL,INC
**** 1 300 100
****
OPTION
**** XM
MAY       10  1976
TIME  15: 9:20.16
RUN   3 HAS STARTED
OUTPUT BELOW
MULTI TOTAL PFL...(   1) AXAVE.(   1) AYMAX.(   1) BETDMX(   1) CUVRAT(   1) SLIPI.(   1) SLIPI.(   2) SLIPI.(   3) SLIPI.(   4)
  1     3      300.       -0.422       0.300       0.252E-01     1.10       0.915E-01     0.825E-01     0.901E-01     0.813E-01
  2     4      400.       -0.533       0.300       0.479E-01     1.16       0.121         0.107         1.00          0.117
  3     5      500.       -0.655       0.300       0.580E-01     0.369      1.00          0.131         1.00          0.156
  4     6      600.       -0.666       0.300       0.738E-01     0.209      1.00          0.999         1.00          1.00
```

Fig. 2-6 IHVHP Interaction for VHTP 2

```
OPTION
****  F
ENTER
****  VHTPNO 3
****
OPTION
****  IC
OPTION
****  F
ENTER
****  STR3 139
****
OPTION
****  MULTI
NUM OF LOOPS,VARS
****  3 2
VAR
****  BMPN
LOOP,VAL,INC
****  1 8 0
****  2 10 0
****  3 13 0
****
VAR
****  BMPS
LOOP,VAL,INC
****  1 57.6 0
****  2 48.0 0
****  3 37.7 0
****
OPTION
****  XM
MAY       10  1976
TIME  15:43:28.49
RUN   2 HAS STARTED
OUTPUT BELOW
MULTI TOTAL BMPN..(   1) BMPS..(   1) AYMAX.(   1) RMAX..(   1) CUVRAT(   1) BETDMX(   1)
  1     2       8.00          57.6         0.584         0.331         0.858         0.129
  2     3      10.0           48.0         0.786         0.389         0.876         0.373
  3     4      13.0           37.7         0.787         0.336         0.793         0.224
```

Fig. 2-7 IHVHP Interaction for VHTP 3

```
OPTION
****  F
ENTER
****  VHTPNO 4
****
OPTION
****  IC
OPTION
****  F
ENTER
****  STR4
   27.93
****
OPTION
****  MULTI
NUM OF LOOPS,VARS
****  4 1
VAR
****  STR4
LOOP,VAL,INC
****  1 55.86 55.86
****
OPTION
****  XM
'MAY        10  1976
TIME  11:11: 1.18
RUN  18 HAS STARTED
OUTPUT BELOW
MULTI TOTAL STR4..(    1) BETAMX(    1) BETDMX(    1) CUVRAT(    1) AYMAX.(    1) RMAX..(    1)
  1    18       55.9         0.105E-01     0.336E-01     0.150          0.189          0.115
  2    19       112.         0.346E-01     0.775E-01     0.346          0.425          0.257
  3    20       168.         0.709E-01     0.125         0.493          0.589          0.386
  4    21       223.         0.112         0.177         0.606          0.687          0.474
```

Fig. 2-8   IHVHP Interaction for VHTP 4

```
OPTION
****  F
ENTER
****  VHTPNO 5
****
OPTION
****  IC
OPTION
****  F
ENTER
****  STR5
   27.93
****
OPTION
****  MULTI
NUM OF LOOPS,VARS
****  4 1
VAR
****  STR5
LOOP,VAL,INC
****  1 55.86 55.86
****
OPTION
****  XM
MAY       10  1976
TIME  11:17:20.88
RUN  22 HAS STARTED
OUTPUT BELOW
MULTI TOTAL STR5..(   1) AYMAX.(   1) DEL...(   1) BETAMX(   1) DELPSI(   1) UIN...(   1)
  1     22       55.9        0.181        9.73       0.141E-01    0.903E-02     45.0
  2     23       112.        0.386        6.40       0.411E-01   -0.135E-02     45.0
  3     24       168.        0.525        4.54       0.829E-01   -0.142E-01     45.0
  4     25       223.        0.640        5.88       0.136       -0.464E-01     45.0
```

Fig. 2-9 IHVHP Interaction for VHTP 5

```
OPTION
****  F
ENTER
****  VHTPNO 6
****
OPTION
****  IC
OPTION
****  F
ENTER
****  BRKON
  0.5200
****
OPTION
****  MULTI
NUM OF LOOPS,VARS
****  3 1
VAR
****  BRKOFF
LOOP,VAL,INC
****  1 0.9 0.05
****
OPTION
****  XM
MAY        10  1976
TIME  16:40:10.20
RUN   2 HAS STARTED
OUTPUT BELOW
MULTI TOTAL PHIMAX(   1) PHIDMX(   1) RMAX..(   1) ZIMX..(   1) ZIMX..(   2) ZIMX..(   3) ZIMX..(   4) UIN...(   1) BRKOFF(   1)
  1     2        7.95         0.748        0.455      -0.208E-02    0.676        0.157        0.330        50.0         0.900
  2     3        8.04         0.721        0.455      -0.208E-02    0.671        0.151        0.331        50.0         0.950
  3     4        8.02         0.682        0.455      -0.220E-02    0.660        0.151        0.334        50.0          1.00
```

Fig. 2-10 IHVHP Interaction for VHTP 6

In the performance of this research over 2000 simulated VHTP's were run. Four vehicles were simulated: Chevrolet Brookwood station wagon, Dodge Coronet, Pontiac Trans Am, and Volkswagen Superbeetle. For each vehicle, a complete set of VHTP's was performed using simulated original equipment (OE) tires. Parametric studies were then performed varying tire parameters to determine their effects on vehicle handling performance. The PCV graphs for the original equipment tire configuration runs are presented in Appendix D of this report.

2.5.1.2 VHTP's for Recreational Vehicles. The HVHP was used extensively for vehicle simulation while APL worked cooperatively with the Dynamic Science Division of Ultrasystems, Inc., on DOT contract HS-4-00853 (Ref. 11). For this research, "Handling Test Procedures for Light Trucks, Vans, and Recreational Vehicles," Dynamic Science was responsible for redefining the HVHP model to simulate a wider class of vehicles. During the course of the contract, the suspension options were broadened to permit simulation of any of the following suspension types:

- Independent front and rear
- Independent front with solid rear axle
- Independent front and solid rear axle with dual rear tires
- Solid front and rear axles
- Solid front and rear axles with dual rear tires

A model representing vehicle aerodynamic properties was also added at this time.

In the performance of the research, over 2500 recreational vehicle VHTP's were run and five vehicles were simulated: Ford F-250 pickup truck equipped with a representative 11-ft camper, Volkswagen Campmobile, Jeep Wagoneer, Open Road motor home (type C), and a Winnebago motor home (type A). Parametric studies were performed on these vehicles to determine appropriate handling test procedures for small trucks and recreational vehicles. This research effort is documented in Refs. 5 and 11.

2.5.1.3 Truck and Bus Tire Effects Program. The HVHP was used extensively for vehicle simulation while APL worked cooperatively with the Highway Safety Research Institute (HSRI), University

of Michigan, on DOT contract HS-4-00943 (Ref. 15). For this research, "Effects of Tire Properties on Truck and Bus Handling," HSRI provided APL with tire model refinements that simplified the simulation of truck tire forces and moments. Trapezoidal and sinusoidal steer VHTP's were performed using simulated OE tires. Parametric studies were then performed using the same VHTP's but varying tire parameters to determine their effects on vehicle handling performance.

In the performance of this research, over 1500 simulated VHTP's were run and four vehicles were simulated: Ford Econoline Van, Ford F-250 pickup truck, White tractor, and a GMC intercity bus.

2.5.1.4 Passenger Cars Pulling Trailers. The HVHP was used for vehicle simulation while APL worked cooperatively with Systems Technology, Inc. (STI) on DOT contract HS-4-00900 (Ref. 16). For this research, "Passenger Cars and Light Trucks Pulling Trailers," STI was responsible for defining a trailer model that was compatible with the HVHP and could be added to it. During the course of this research, a model of a one- or two-axle trailer connected to a tow vehicle with a ball hitch was incorporated into the HVHP. Braking, steering, and combined braking and steering simulation runs were performed. The simulated tow vehicle was a Chevrolet Caprice station wagon and the towed vehicle was a single-axle trailer.

2.5.1.5 Sublimit Performance Maneuvers. The HVHP simulation was modified to incorporate various steering and suspension degradations during a research study with STI (Ref. 17). The simulation results were used in the selection of maneuver and component degradation levels for full-scale vehicle testing.

2.5.1.6 Development of Vehicle Rollover Maneuver. During this research effort with the Calspan Corporation, the IHVHP evolved.

Ref. 15. Research on the Effects of Tire Properties on Truck and Bus Handling, Final Report, Contract DOT HS-4-00943, Highway Safety Research Institute, University of Michigan, June 1976.

Ref. 16. Research on Passenger Cars and Light Trucks Pulling Trailers, Final Report, Contract DOT HS-4-00900, Systems Technology, Inc., June 1976.

Ref. 17. Development of Vehicles - In-Use Sub-Limit Maneuvers, Final Report, Contract DOT HS-5-01191, Systems Technology, Inc., May 1977.

The computing tasks between the analog and digital computers were redistributed. Many of the simplifications that existed in the HVHP were removed. The major modifications are:

1. Expansion of the equations of motion for the sprung and unsprung masses to include the higher order terms,

2. Expansion of the calculation of inertial terms to include the time-varying effects of unsprung mass movements,

3. Modification of the calculation of Euler angles and vehicle position to eliminate the small-angle assumption for roll and pitch,

4. Modification of the calculation of the resultant forces and moments applied to the vehicle to eliminate the small-angle assumption for roll and pitch,

5. Modification of the calculation of wheel center height above the ground to allow large pitch and roll angles,

6. Modification of the calculation of tire contact point velocities to include time-varying unsprung mass positions,

7. Modifications of the calculations of wheel velocity in the ground plane to account for large pitch and roll angles,

8. Change of the computation of tire forces using tire force normal to the ground rather than tire radial force,

9. Modification of the wheel slip angle calculation to include the steer angle in the ground plane rather than the steer angle with respect to the vehicle, and

10. Modification of the calculation of camber angle with respect to the road to eliminate the small angle assumptions on vehicle pitch and roll.

In the past year, the IHVHP has been used for many NHTSA research efforts pertaining to vehicle handling during braking and/or steering maneuvers and is presently being used to study the influences of aerodynamic disturbances on vehicle handling, an NHTSA research study conducted by STI.

During the course of a recent study concerning passenger car braking performance, APL incorporated a Kelsey-Hayes Anti-Lock model into the IHVHP. The NHTSA study was conducted by HSRI which supplied the antilock math model.

2.5.2 Vehicle Handling Test Procedures

Time histories for a typical set of VHTP maneuvers are presented in Figs. 2-11 to 2-16. The vehicle simulated for these runs was the 1971 Dodge Coronet. A general discussion of IHVHP simulation output is presented in Appendix E.

2.5.2.1 Straight Line Braking. This run series determines the value of brake line pressure at which two wheels on the same axle lock up. For this vehicle, both rear wheels were locked at 500 psi and all four wheels were locked at 600 psi.

2.5.2.2 Braking In a Turn. This run series determines the value of brake line pressure at which two wheels on the same axle lock up while the vehicle is executing a constant 0.3-g turn. For this vehicle, the inside rear wheel was locked at 400 psi, both inside wheels were locked at 500 psi, and all four wheels were locked at 600 psi.

2.5.2.3 Turning On a Rough Road. For this run series, the vehicle traverses a bump grid while in a steady 0.4-g turn. Three grid frequencies are simulated: 9, 11, and 14 Hz.

2.5.2.4 Trapezoidal Steer. In this run series, trapezoidal steers of 4, 8, 12, and 16° of normalized steer angle were used. For this vehicle, 28° of steering wheel angle is required for 2° of normalized steer.

2.5.2.5 Sinusoidal Steer. In this run series, sinusoidal steers with a maximum amplitude of 4, 8, 12, and 16° of normalized steer angle were used. For this vehicle, 28° of steering wheel angle is required for 2° of normalized steer.

2.5.2.6 Drastic Steer and Brake. The purpose of these runs is to determine vehicle roll-over tendency. For this vehicle, a peak roll angle of 0.14 rad and a peak roll rate of 0.75 rad/s were achieved.

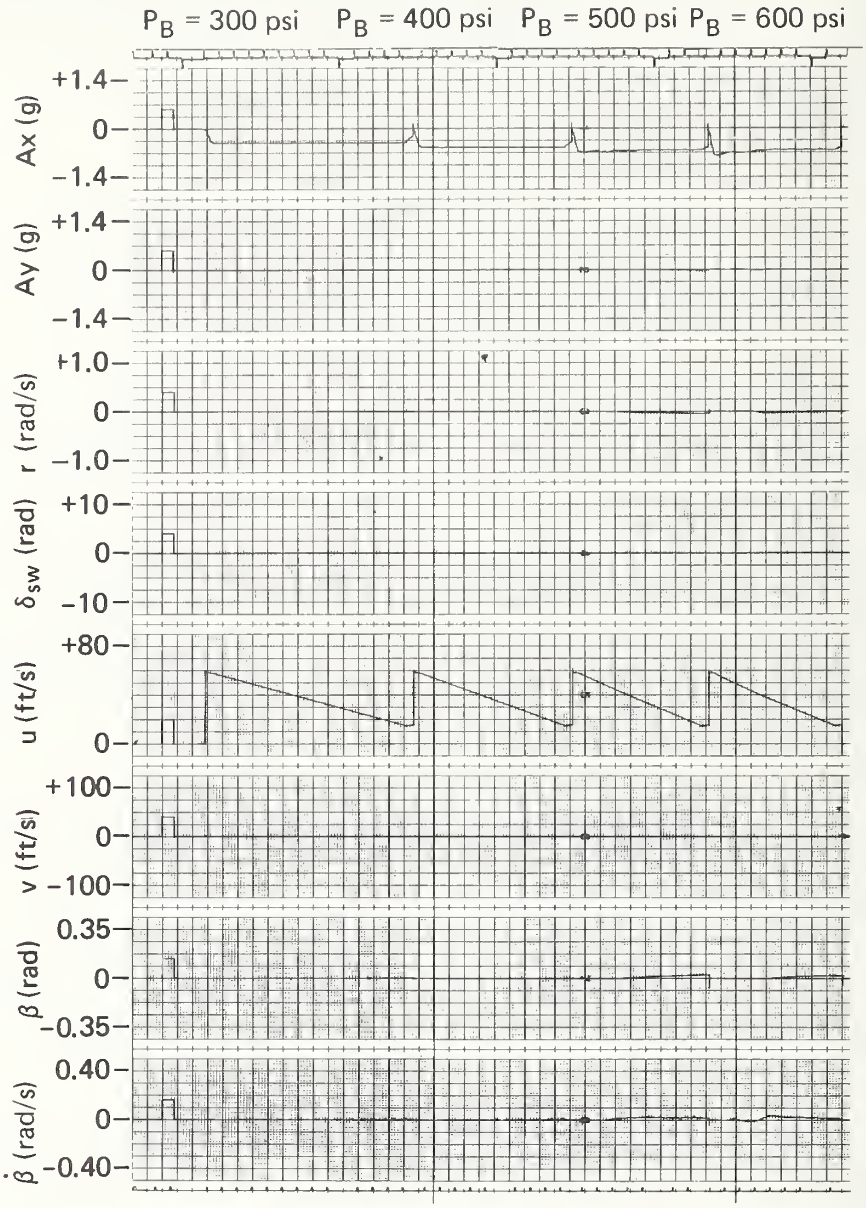

Fig. 2-11 Time Histories — Straight Line Braking (p. 1)

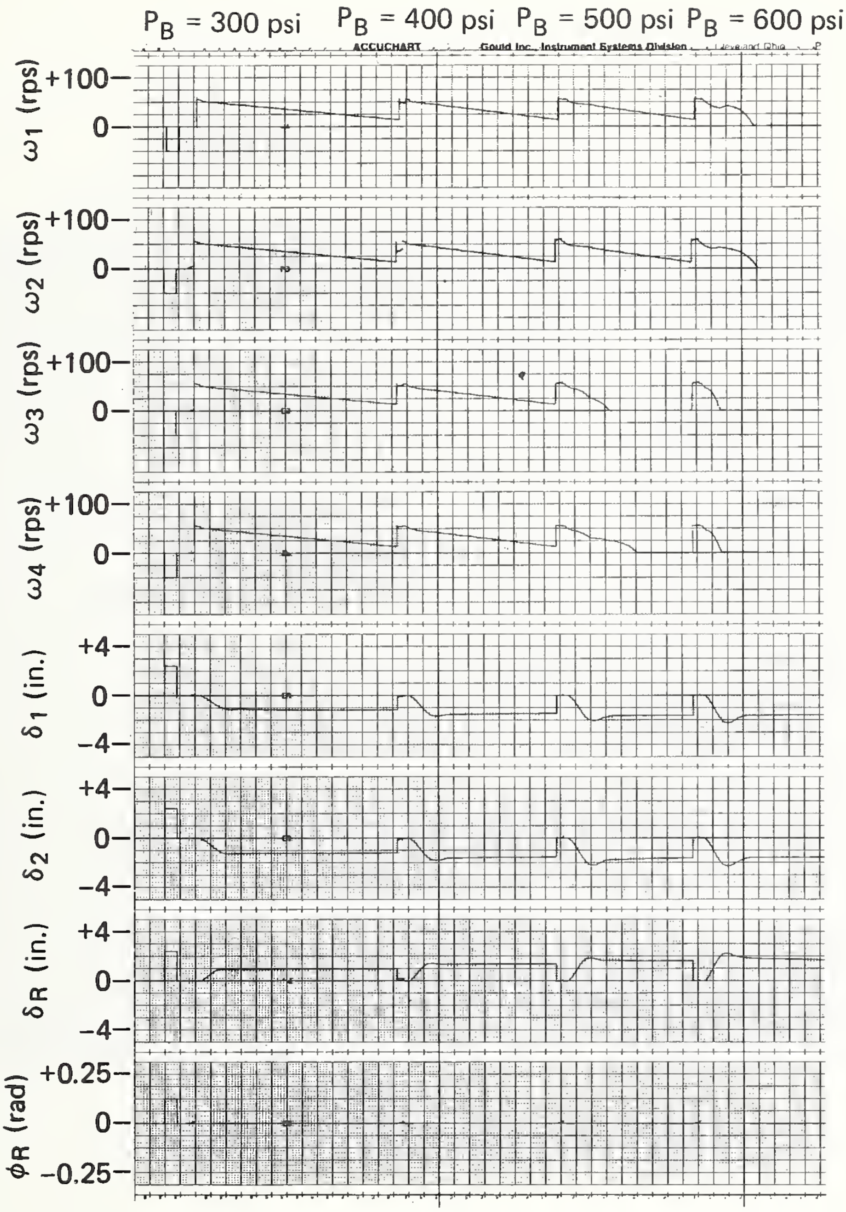

Fig. 2-11 Time Histories – Straight Line Braking (p. 2)

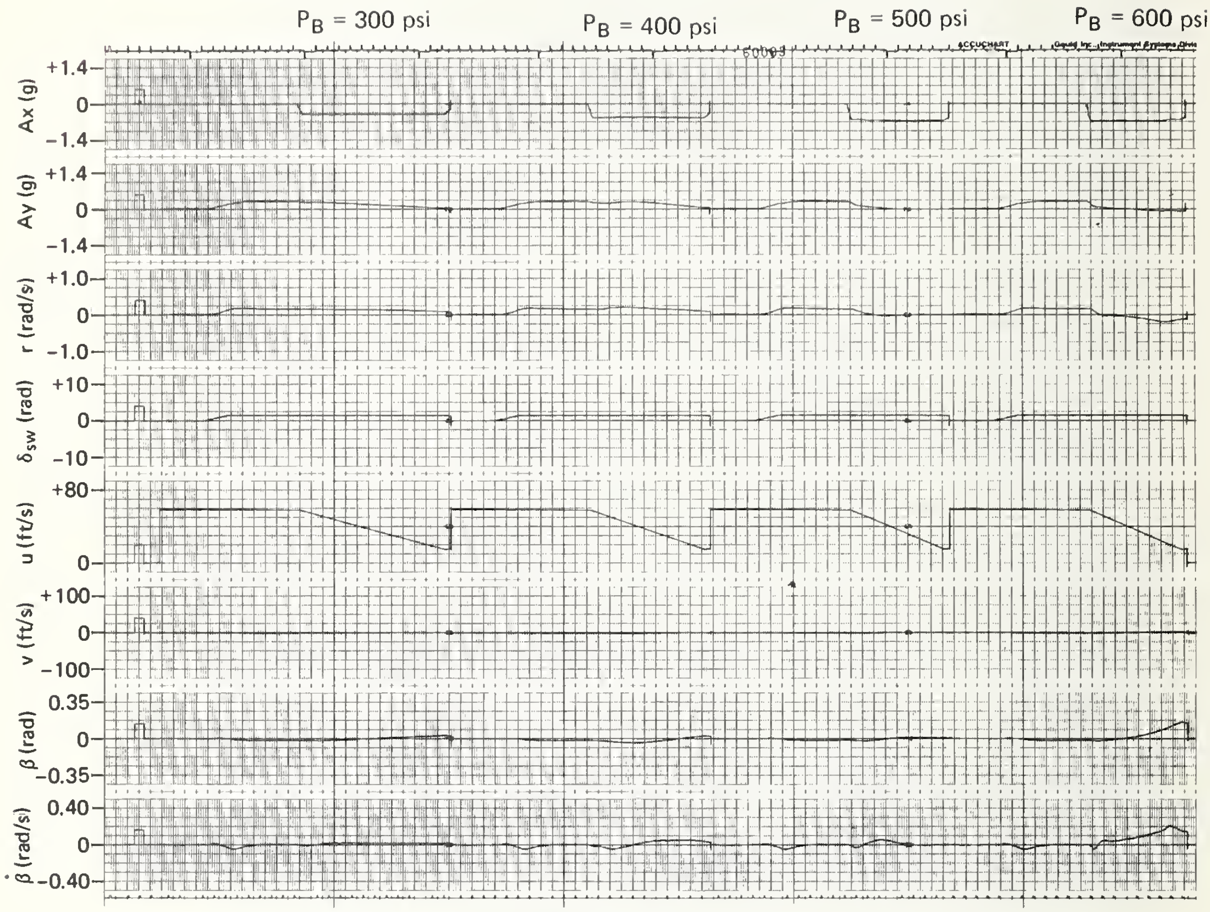

Fig. 2-12 Time Histories — Braking in a Turn (p. 1)

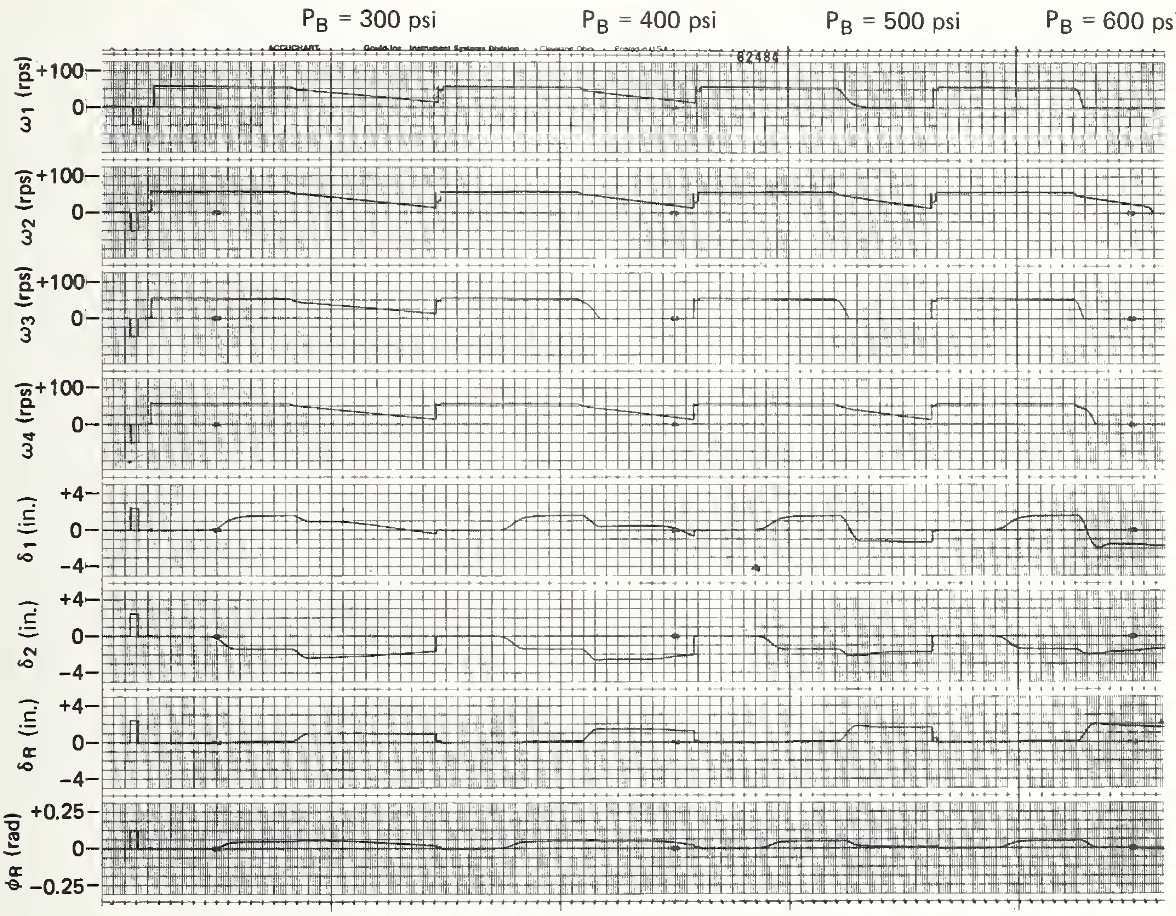

Fig. 2-12 Time Histories – Braking in a Turn (p. 2)

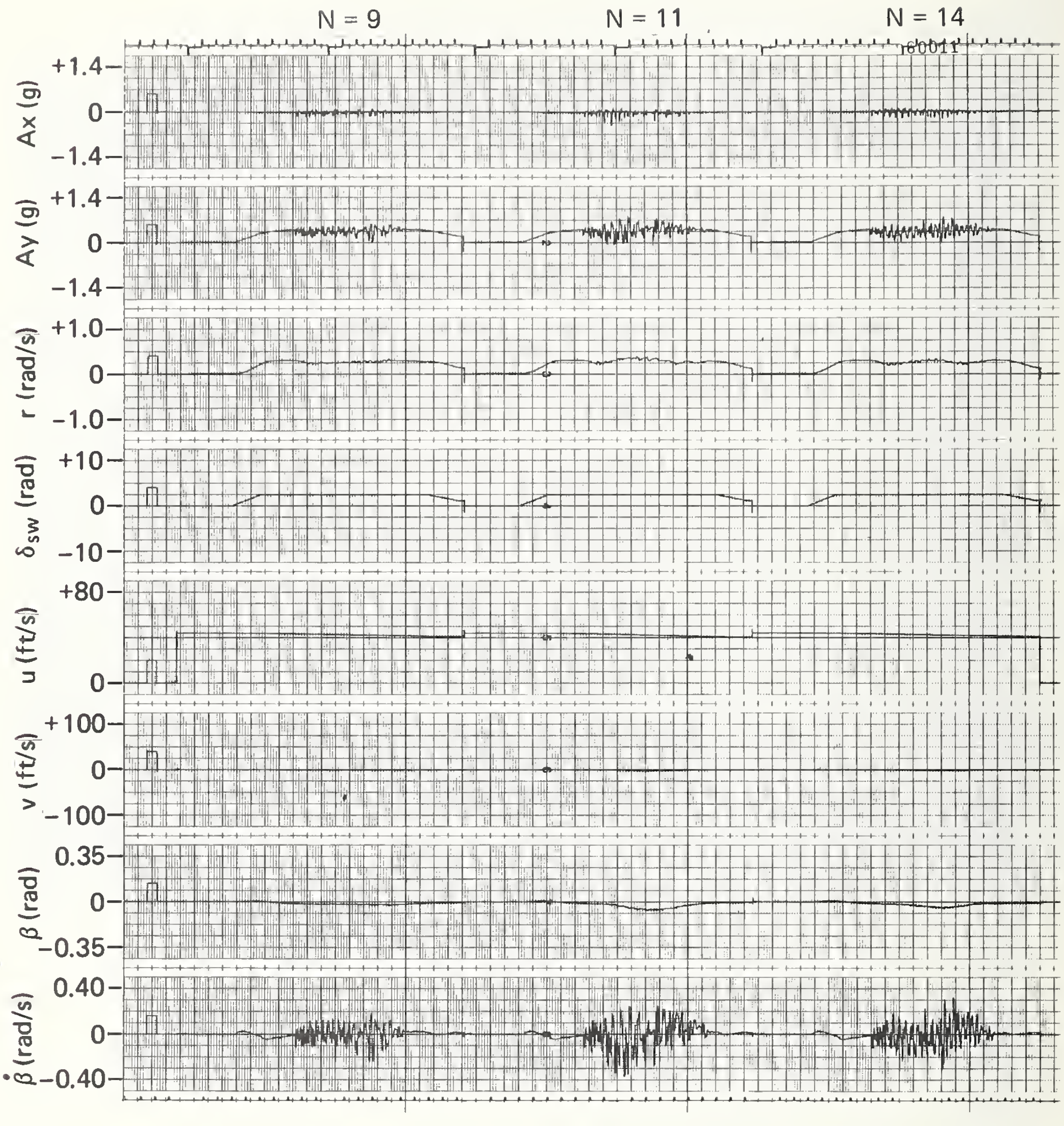

Fig. 2-13 Time Histories – Turning on a Rough Road (p. 1)

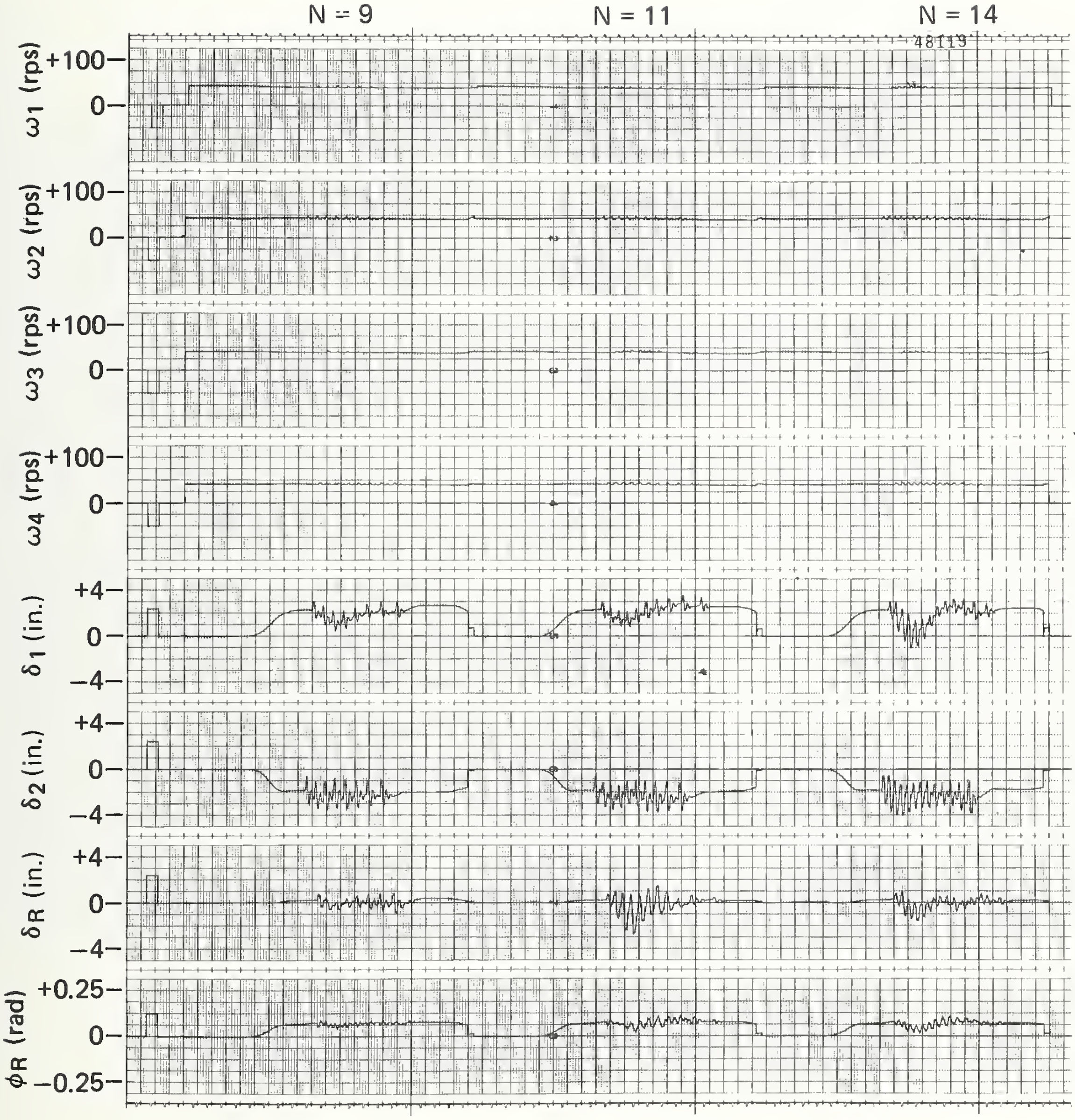

Fig. 2-13 Time Histories – Turning on a Rough Road (p. 2)

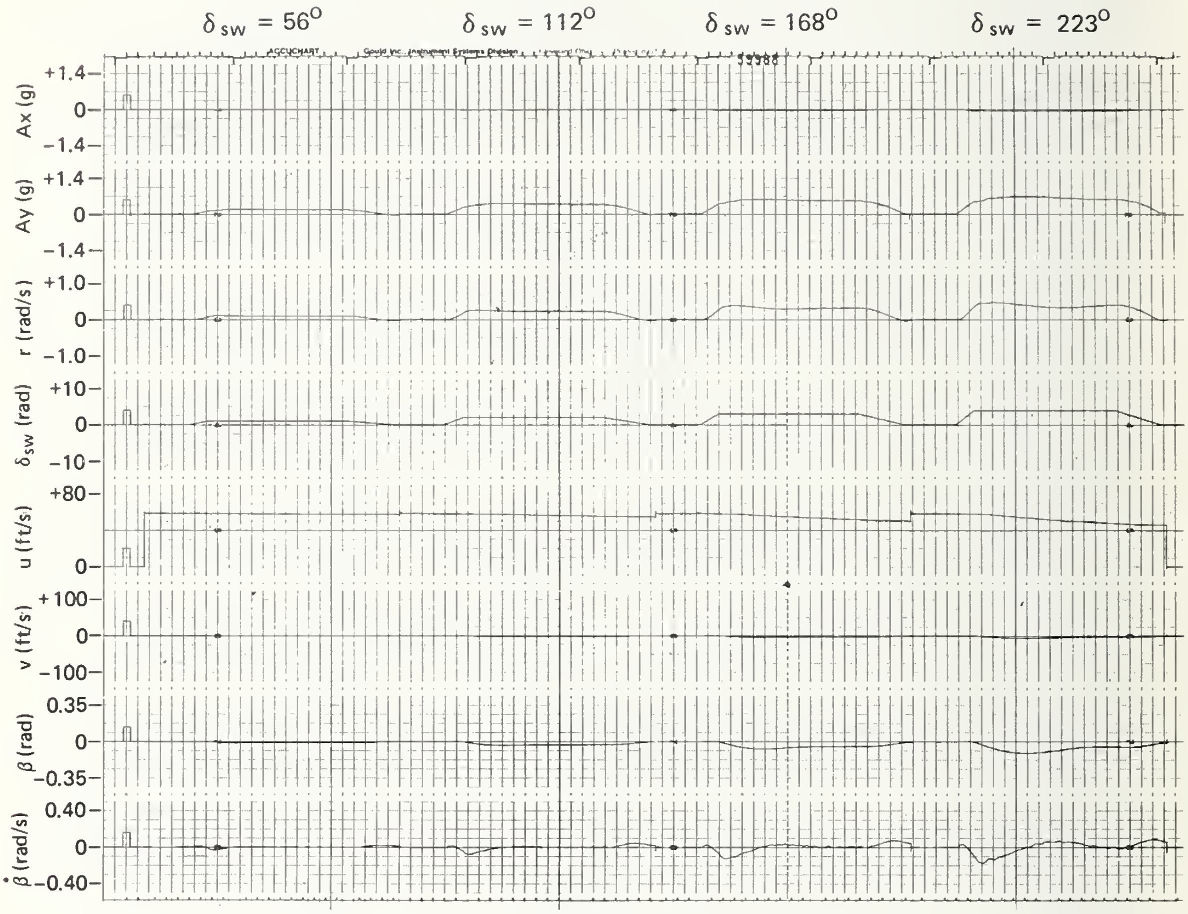

Fig. 2-14 Time Histories — Trapezoidal Steer (p. 1)

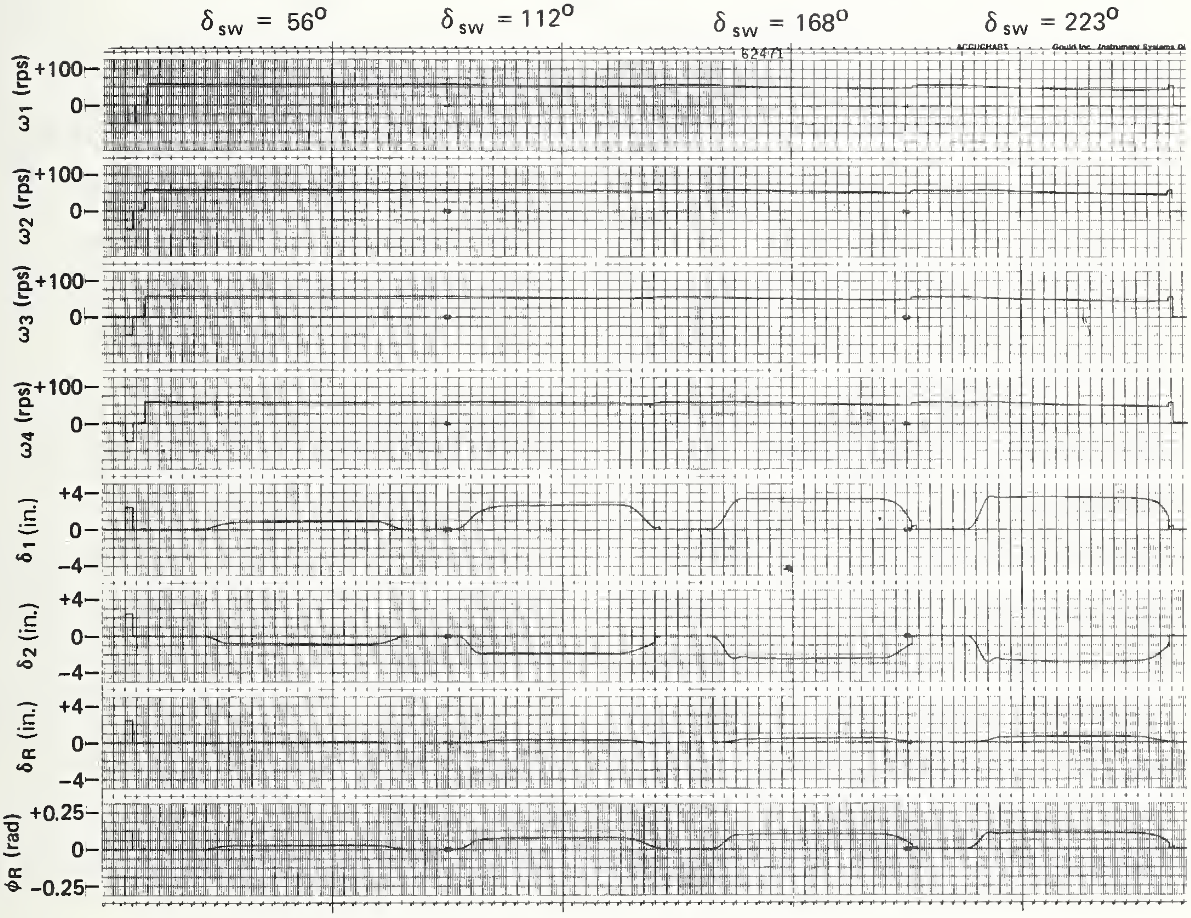

Fig. 2-14 Time Histories — Trapezoidal Steer (p. 2)

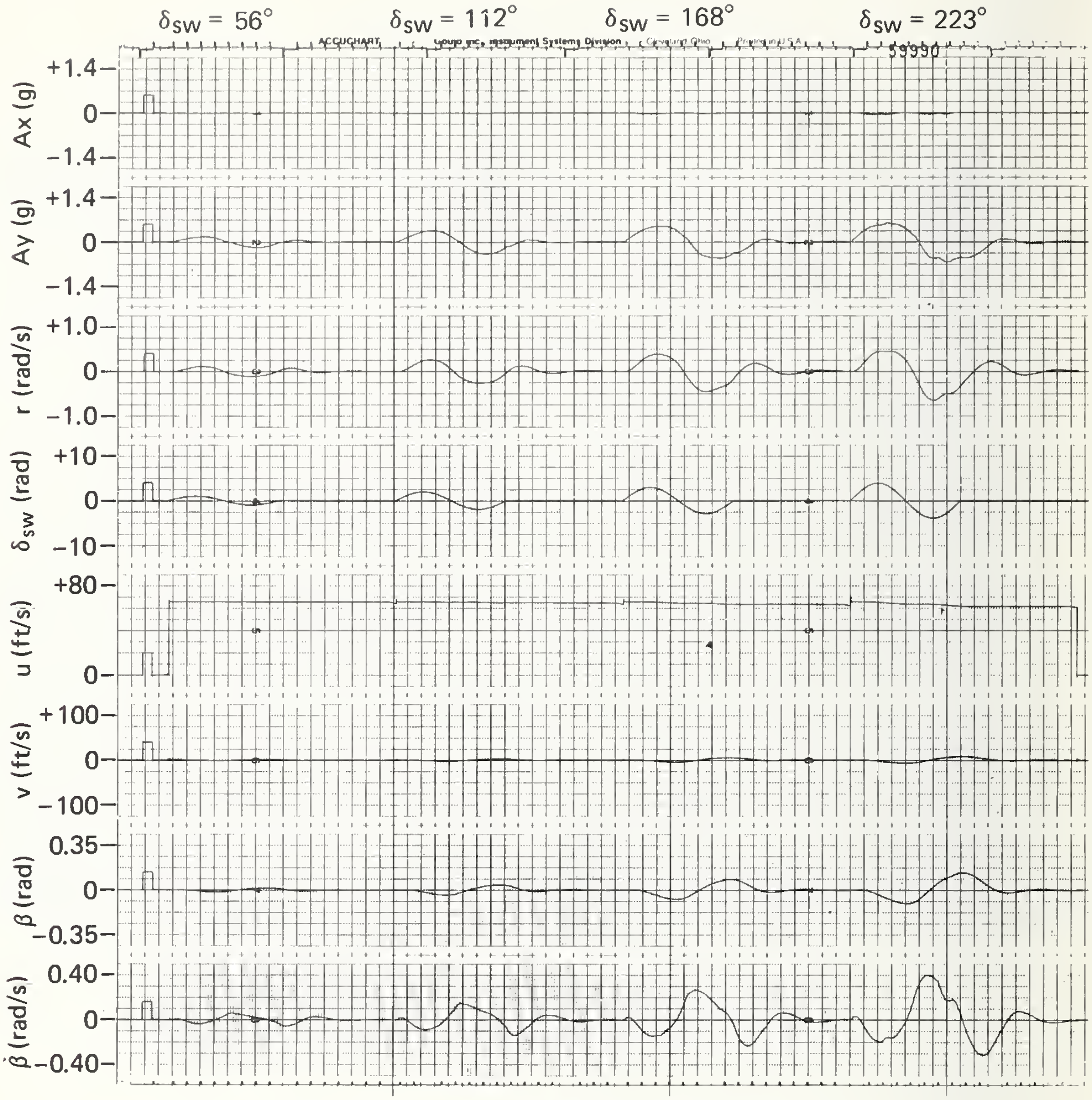

Fig. 2-15 Time Histories — Sinusoidal Steer (p. 1)

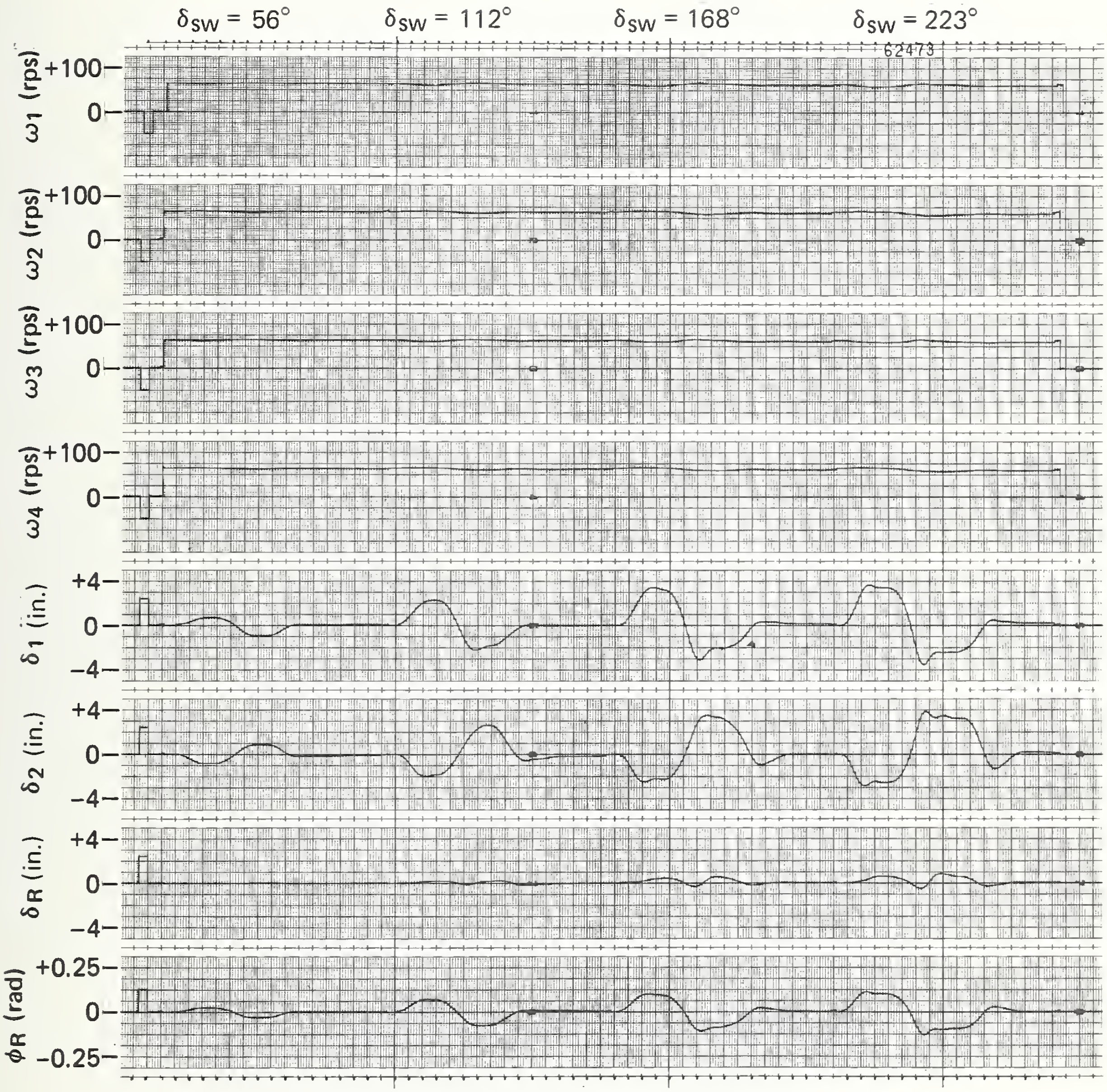

Fig. 2-15 Time Histories — Sinusoidal Steer (p. 2)

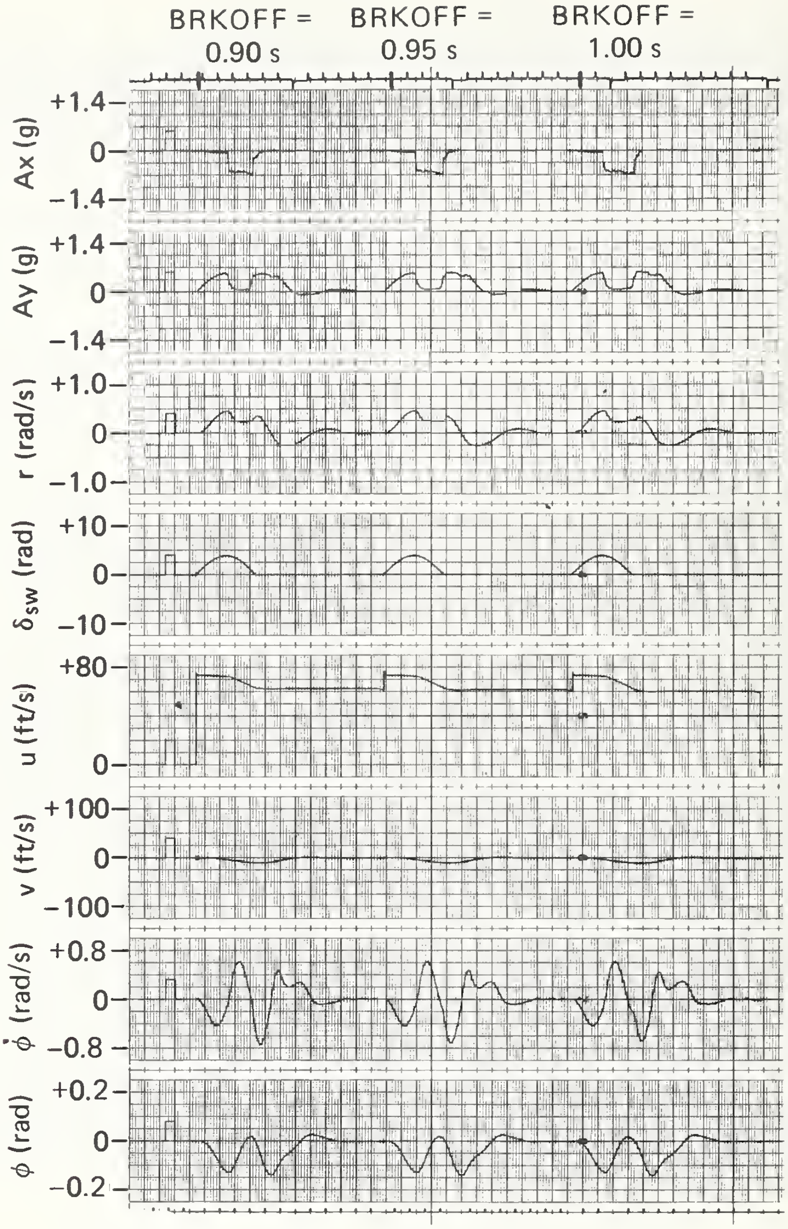

Fig. 2-16 Time Histories — Drastic Steer and Brake (p. 1)

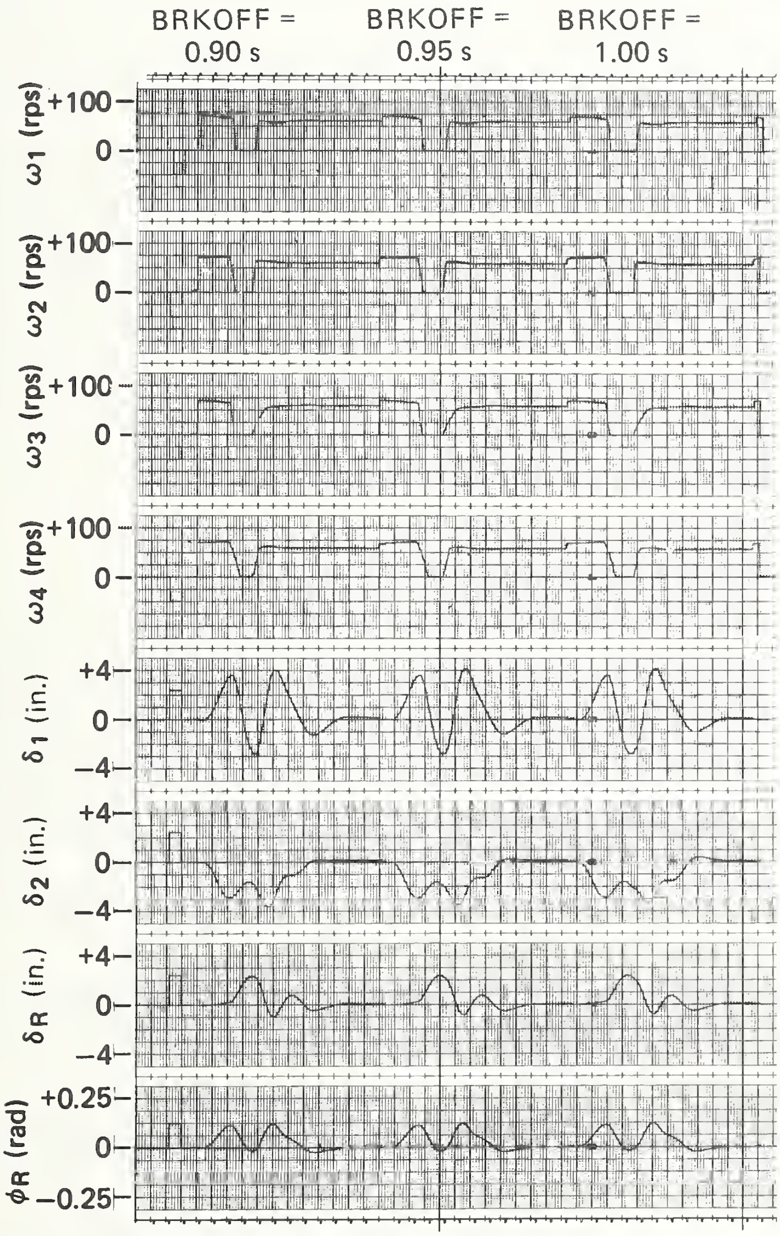

Fig. 2-16 Time Histories — Drastic Steer and Brake (p. 2)

2.6 TIRE DATA

As previously stated, the current IHVHP tire/road interface model was defined by Calspan as part of DOT contract HS-053-3-727 (Ref. 6). For this contract, Calspan tested many tires at their Tire Research Facility (TIRF) testing complex (Ref. 18). As a convenience for working with APL and using the IHVHP, the TIRF-associated computer was programmed to process tire data into a format directly compatible with the IHVHP tire model. Therefore, very little effort is required to prepare tire data for input on the TIRF machine. For tires tested on other tire test machines or flatbed testers, APL can convert the data for IHVHP use with the TIRF computer data processing program. When the tire test data have been properly formatted, the program output will be compatible with the IHVHP. However, data preparation for the latter approach can be very time consuming. A recent tire parameter determination research program has made available IHVHP-compatible data on approximately 400 tires of sizes usually found on passenger cars and light trucks. These tire data along with documentation of the research can be found in Ref. 19.

2.6.1 Tire Data Validation

A tire/road interface plotting program (Ref. 20) was developed at APL to validate tire model data used as input to the vehicle simulation. The validation approach was to generate families of curves of desired tire/road interface functions for chosen sets of conditions that could be correlated with data obtained from tire tests. Given values for the coefficients and parameters of the tire model equations, the program calculates the tire model functions and produces a data deck compatible with the input requirements of a Calcomp plotting subprogram (Ref. 21). Tire/road in-

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Ref. 18. K. D. Bird and J. F. Martin, "The Calspan Tire Research Facility: Design, Development and Initial Test Results," SAE Paper 730528, May 1973.

Ref. 19. D. J. Schuring, Tire Parameter Determination, Final Report, Contract DOT HS-4-00923, Calspan Corporation, December 1975.

Ref. 20. R. E. Sienicki, "Tire/Road Interface Plotting Program User's Guide and Program Documentation," APL/JHU Memorandum BCE-T-0590, December 1975.

Ref. 21. L. Klein and N. Rubinstein, "General Linear, Semi-Log and Log-Log Calcomp Plot Subroutine (FORTRAN IV)," APL/JHU Memorandum F1C(2)-75-U-026, November 1975.

terface graphs are then generated by the subprogram. Included in TIRF data from Ref. 19 are three carpet plots for each tire: (a) lateral force versus slip angle at various loads, (b) lateral force versus slip angle at various camber angles, and (c) braking force coefficient versus slip ratio at various loads. The same types of carpet plots are generated from the APL plot program and compared with the TIRF plots for validation. Representative graphs are shown in Appendix F.

2.7 IHVHP INPUT DATA

2.7.1 Data Deck Description

A general input data deck is used with the IHVHP. The following are defined in the data deck:

- Program identification;
- Default output variable list for the Track OPTION;
- Default output variable list for the Table OPTION for VHTP's performed in the multiple-run mode;
- Digital-to-analog converter variable and scale-factor assignments input as pairs of digital variable and corresponding scale factor;
- Analog-to-digital converter variable and scale-factor assignments input as pairs of digital variable and corresponding scale factor;
- Initialization of non-integer parameters for initial conditions;
- Initialization of integer parameters for initial conditions;
- Vehicle simulated;
- Front and rear camber, caster, and toe functions via coefficients for a fifth order polynomial approximation;
- Front and rear brake torques as pairs of brake pressure in, brake torque out data points;
- Lateral friction coefficient degradation with circumferential slip as pairs of percent of slip in, percent of lateral friction coefficient out data points;

- Wind profile data as pairs of distance in, wind velocity out data points;

- Aerodynamic force and moment coefficients as a function of aerodynamic sideslip angle or angle of attack in, aerodynamic coefficient out data points;

- Steer profile data as pairs of steer time in, steer angle out data points;

- Front and rear spring data as pairs of suspension deflection in, spring force out data points;

- Front and rear shock absorber data as pairs of suspension velocity in, shock absorber force out data points;

- PARAM data array members that are used to redefine VHTP condition inputs as sequential numbers representing the PARAM array element number and the corresponding variable value for the initial check run and each VHTP number from 1 to 6; and

- Initial values of individual members of the PARAM vehicle descriptor data array input as pairs of array element number and initial value.

The input data for three simulated vehicles that are representative of the IHVHP suspension types are presented in Appendix G, along with a sample for each vehicle of the PARAM table that is output to the system line printer prior to each simulation run. The tables provide PARAM value documentation. The three vehicles for which data are provided are

- VW Campmobile, independent front and rear suspension;

- Dodge Coronet, independent front, with solid rear axle; and

- Winnebago motor home, solid front and rear axles with dual rear tires.

2.7.1.1 Program Identification. The first data card identifies the APL problem number, the digital computer load module, and the vehicle simulated.

2.7.1.2 Track Output Variables. The next group of cards defines the initial set of interactive variables to be output when

the Track OPTION is enabled. Fifty variables may be selected on as many cards as required. This group of cards is terminated by a blank card. The list may be altered interactively using the Track OPTION.

2.7.1.3 Table Output Variables. The next group of cards defines the variables to be output at the end of each run when the multiple-run execution mode is enabled. This group contains seven cards, one for each VHTP (the first six) and one for the check run. A maximum of nine variables can be specified per card. If the table variables are respecified interactively via the Table OPTION for the execution of a VHTP, the variables in this data group will be restored when that VHTP is reselected.

2.7.1.4 Digital-to-Analog Variables. This group of cards specifies which variables will be output from the digital to the analog computer and the scale factor that will be associated with digital-to-analog conversion. Any variable may be output. If the output variable is used in the closed loop vehicle model, the scale factor must be consistent with the use of the variable on the analog computer. If the output variable is used strictly for strip chart recorder display purposes, the scale factor can take any rational value. The maximum expected value of the variable is an appropriate starting value. Either the variable, the scale factor, or both may be reassigned via the interactive OPTION DACA. Forty-eight cards must be included, one for each digital-to-analog output in the order of assignment to DAC's 0 to 47. Each card contains a variable name followed by its normalizing scale factor. The list is terminated by the character string ENDNODAC.

2.7.1.5 Analog-to-Digital Variables. This group of cards specifies which variables will be input from the analog to the digital computer and the scale factor that will be associated with analog-to-digital conversion. Any variable name that has been specified may be input. The scale factor must be consistent with the use of the variable on the analog computer. The variable, the scale factor, or both may be reassigned via the interactive OPTION ADCA. A change in variable implies a wiring change on the analog patch panel. Thirty-eight cards must be included, one for each analog-to-digital input in the order of assignment to ADC's 0 to 37 (only 38 of the 48 ADC channels are used by the IHVHP). Each card contains a variable name followed by its analog scale factor. The list is terminated by the character string ENDNOADC.

2.7.1.6 Non-Integer Variable Initialization. The next group of cards allows any non-integer initial condition or parameter that has been specified as an interactive variable to be

assigned an initial value. The format is a name followed by the initial value with a maximum of 10 pairs per card. Any number of cards is allowed, and the input is terminated by a blank card.

2.7.1.7 Integer Variable Initialization. The next group of cards allows any integer parameter that has been specified as an interactive variable to be assigned an initial value. The format is a name followed by the initial value with a maximum of 10 pairs per card. Any number of cards is allowed, and the input is terminated by a blank card.

2.7.1.8 Vehicle Identification. This data card is used to document the vehicle being simulated. Any message up to 80 characters is allowed.

2.7.1.9 Camber, Caster, and Toe Functions. The next six data cards define the front and rear wheel camber, caster, and toe functions in degrees for wheel displacement (in.) from the unloaded vehicle suspension equilibrium position. One function is defined per data card, which contains the six coefficients required to specify a fifth order polynomial approximation to the appropriate function. The order of the data is C0, C1, ..., C5. C0 is the value of the function (camber, caster, toe) at the equilibrium suspension position of the unloaded vehicle. The vehicle simulation uses the right front and rear wheels as a reference for camber and toe data. The sign of the coefficients for the left front and rear wheels is changed in the digital program. Data for these functions for the representative vehicles are presented in Appendix G.

2.7.1.10 Brake Torques. The next group of data cards defines the front and rear brake torque functions. The function is specified as pairs of data points with one pair per card, a value of brake line pressure (lb/in^2) and the corresponding value of the brake torque (lb-in.). A group of cards (2 to 19) defining each function is ended by a data card containing the number 99999. A linear interpolation routine is used to obtain torque values for brake line pressures between specified data values. Conventionally, the front and rear brake torque funtions are identical, and brake proportioning is accomplished using PARAM array elements 238 to 241.

2.7.1.11 Side Force Shaping Function. The next group of data cards defines the functional relationship between the side force and circumferential slip. Pairs of data points are input with one pair per card, as percent of slip and the corresponding

percent of possible side force that is attained. The function data (2 to 19 cards) are terminated by a card containing the number 99999. Linear interpolation is used between data points to obtain intermediate function values.

2.7.1.12 Wind Profile. The next group of data cards defines the aerodynamic wind disturbance profile. Pairs of data points are input as tabular functions of longitudinal distance to the center of the wind disturbance profile and cross-wind velocity. The function is input as pairs of data points, one pair per card, with a maximum of 19 cards. The format is a distance (in.) followed by the wind velocity (in./s). The data points are terminated by a card containing 99999. A linear interpolation routine is used to obtain cross-wind velocity for longitudinal distance between specified data points.

2.7.1.13 Aerodynamic Coefficients. The next group of data cards (39 maximum) defines the aerodynamic force and moment coefficients as tabular functions of the aerodynamic sideslip angle. The format is sideslip angle (rad) followed by the value of the aerodynamic coefficient. The input order of the functions is axial force (C_x), side force (C_y), normal force (C_z), roll moment (C_1), pitch moment (C_m), and yaw moment (C_n). The data array is terminated by the number 99999. The next group of data cards defines the increment in axial force coefficient as a tabular function of aerodynamic angle of attack. The function is input as pairs of data points, one pair per card, with a maximum of 39 cards. The format is an angle of attack (rad) followed by the value of the aerodynamic coefficients (ΔC_x). The function data cards are terminated by the number 99999. A linear interpolation routine is used to obtain functional values for sideslip angles or angles of attack between specified data values.

2.7.1.14 Steer Profile. The next group of data cards (19 maximum) defines the functional relationship between the steer angle (rad) and time (s). Pairs of data points are input as time and steer angle. The data are terminated by a card containing the number 99999. Linear interpolation is used to obtain functional values between specified time data points.

2.7.1.15 Spring Functions. The next groups of cards define the front and rear spring functions as tabular functions of suspension deflection from the equilibrium position. Each function is input as pairs of data points, one pair per card, with a maximum of nine cards. The format is a suspension deflection

(in.) followed by the spring force (lb). The data are input for the range from full compression to full rebound. The input order of the spring forces is right front, left front, right rear, and left rear. Each function's data cards are terminated by the number 99999. A linear interpolation routine is used to obtain function values for deflections between specified data values.

The spring force at each wheel is implemented as the sum of a linear segment generated on the analog computer and a digital supplement that is the difference between the analog value and the actual spring characteristic. The sign convention for deflections from equilibrium, which is zero (in.) with a corresponding suspension force of zero (lb), is that

- Compression is a negative deflection and produces a negative suspension force, and

- Rebound is a positive deflection and produces a positive suspension force.

Spring data for three representative vehicles are presented in Appendix G.

2.7.1.16 Shock Absorber Functions. The next group of data cards defines the front and rear shock absorber characteristics as tabular functions of suspension velocity. Each function is input as pairs of data points, one pair per card, with a maximum of nine cards. The format is the suspension velocity (in./s) followed by the shock absorber force (lb). The data are input for the range from full compression to full extension. The input order of the shock absorber forces is right front, left front, right rear, and left rear. Each function's data cards are terminated by the number 99999. A linear interpolation routine is used to obtain function values for suspension rates between specified data.

The shock absorber force at each wheel is implemented as the sum of a linear segment generated on the analog computer and a digital supplement that is the difference between the analog value and the actual shock absorber characteristic. The sign convention for the suspension motion from equilibrium, which is zero rate (in./s) and a corresponding zero damping force (lb), is

- A negative suspension deflection rate (compression motion) produces a negative shock absorber force, and

- A positive suspension deflection rate (rebound motion) produces a positive shock absorber force.

Shock absorber data for three representative vehicles are presented in Appendix G.

2.7.1.17. VHTP Initialization Data. The next group of cards allows the input of data that are used for initialization of the simulation for performing a specific VHTP maneuver. Since the data are input, VHTP conditions can easily be varied. Twenty-seven data cards are required, with each card containing a PARAM element address and a value for the variable represented by that address for the check verification run and each VHTP 1 to 6, in that order. The PARAM element addresses shown in the data lists are required for VHTP initialization. However, the input order is not fixed.

2.7.1.18. Vehicle Descriptor and Tire Data. The last group of cards is used to input the initial values of variables that are elements of the PARAM data array. The array is used to input all vehicle descriptor and tire model data. Since the array is also used for purposes other than data input, such as storing values for program calculated initial conditions, program flow switch values, etc., all PARAM elements need not be initialized. The definitions of all PARAM elements are given in Section 4 of Appendix H. The subset of PARAM elements that represents vehicle descriptors or tire model coefficients is presented in Section 5 of Appendix H. Data are input one PARAM element per card by indicating the PARAM element address followed by the assigned value.

2.7.2. Load-Dependent Data

Since the IHVHP calculates suspension deflections relative to the suspension equilibrium position for all load configurations, information specifying the suspension travel from the unloaded vehicle suspension position must be provided. Of particular interest are the loaded vehicle configurations for driver control used in VHTP's 1 through 3 and for automatic control used in VHTP's 4 through 6. The vehicle parameters that are load dependent and their corresponding PARAM element addresses are as follows:

Parameter	PARAM Address	Parameter	PARAM Address
MS	1	IX	11
ZF	4	IY	12
ZR	5	IZ	13
A	6	DELF	92
B	7	DELR	93

Section 3

CONCLUSIONS AND RECOMMENDATIONS

The Improved Hybrid Computer Vehicle Handling Program (IHVHP) has demonstrated realistic dynamic simulations of passenger vehicles and trucks with suspensions ranging from four-wheel independent to solid front and rear axles. The performance of simulation runs, especially those involving the six Vehicle Handling Test Procedures (VHTP's), are inexpensively and easily performed. In addition, the performance measuring vehicle performance comparison variables (PCV's) for each VHTP are provided.

Although good correlation between the IHVHP and full-scale test data has been achieved, it is recommended that changes in all areas of the model, including the tire/road interface and vehicle description, be given serious consideration where an improvement in correlation could result. The IHVHP has proved to be a good simulation that is easily extended to meet the increasing needs of predicting vehicle behavior. By critically reviewing the simulation with each use and making improvements, the IHVHP will continue to be a successful engineering tool.

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Appendix A

VEHICLE MATHEMATICAL MODEL

1. INTRODUCTION

This appendix contains the vehicle mathematical model that was implemented on the APL/JHU hybrid computer. The equation numbers associated with a particular suspension, axial, or tire configuration will include a notation from the following legend:

A. Solid front axle

B. Solid rear axle

C. Independent front suspension

D. Independent rear suspension

E. Solid front and rear axles

F. Independent front suspension and solid rear axle

G. Independent front and rear suspensions

H. Independent f ont suspension and dual tires on solid rear axle

I. Solid front axle and dual tires on solid rear axle

Figure A-1 is a block diagram of the Improved Hybrid Vehicle Handling Program (IHVHP), and Figs. A-2 and A-3 are analytical representations of the vehicle and solid-rear-axle models, respectively. (The reader should note that the figures are repeated here from the main body of the text for convenience.)

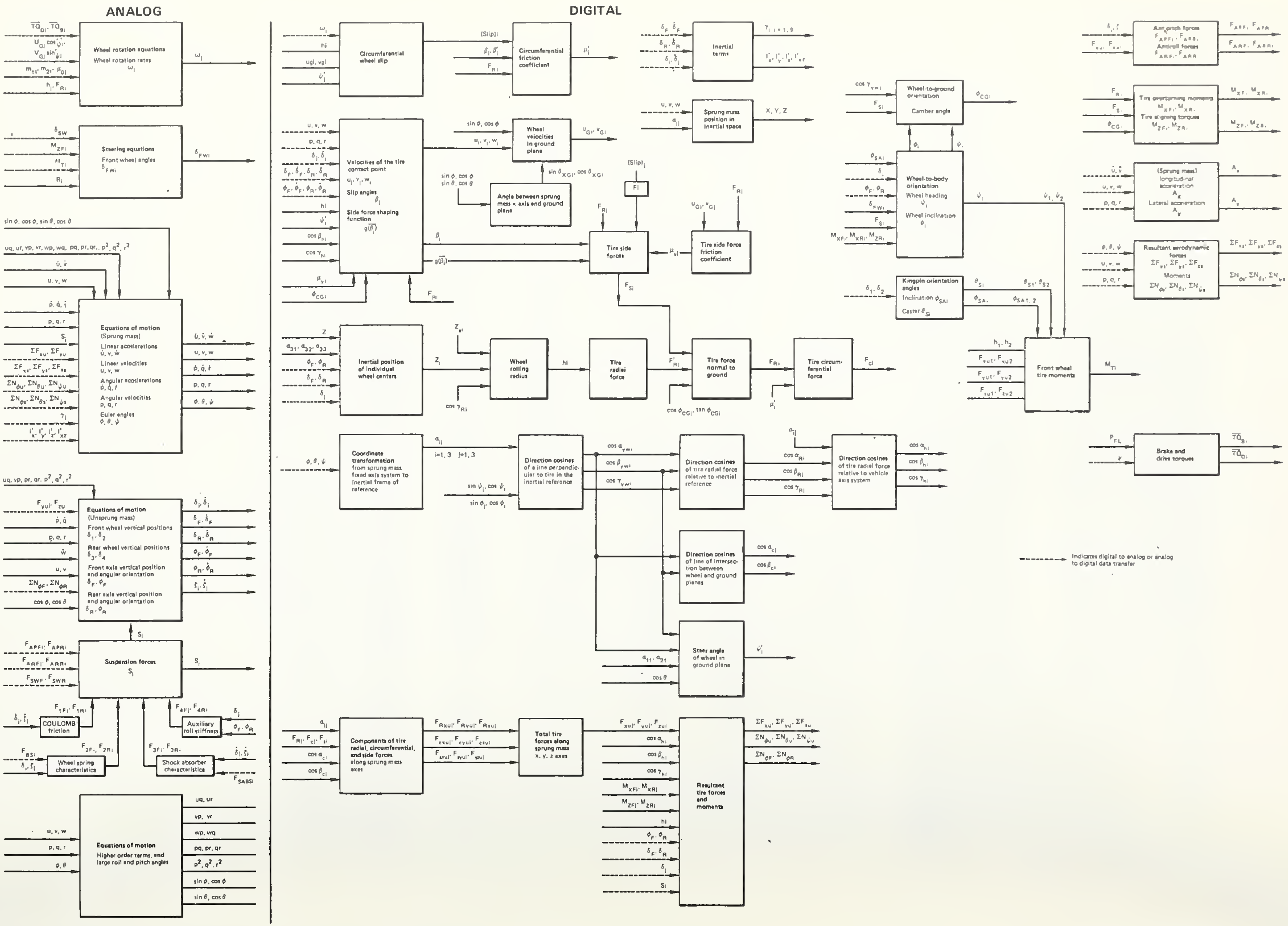


Fig. A-1 Hybrid Simulation Block Diagram of the IHVHP Model

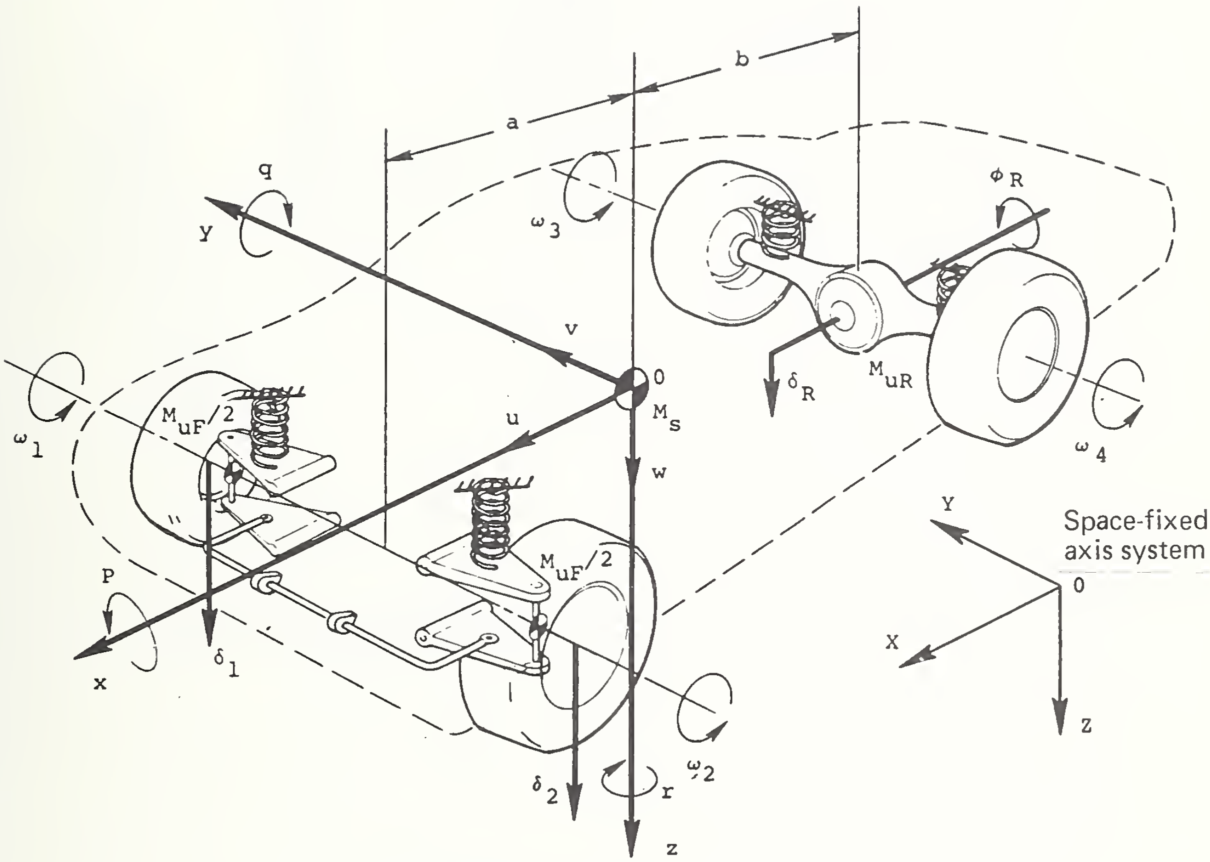


Fig. A-2 Analytical Representation of the Vehicle Model

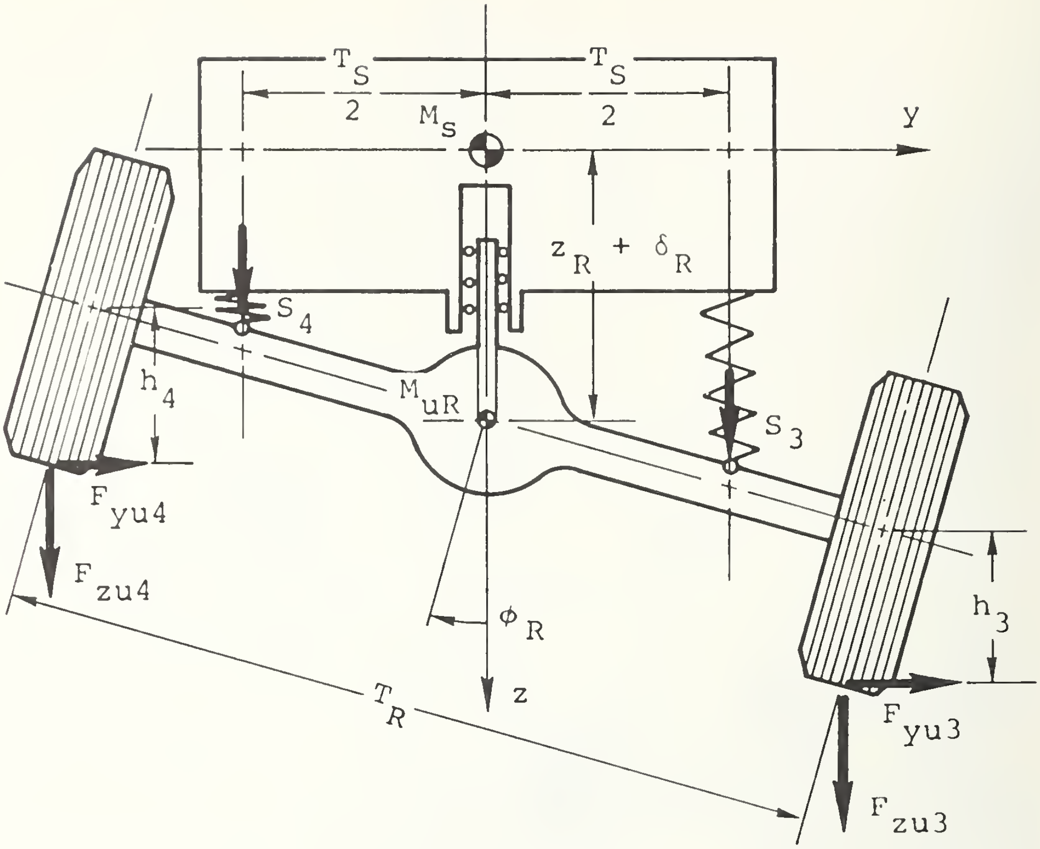


Fig. A-3 Analytical Representation of the Solid Rear Axle Model

2. SYSTEM EQUATIONS

2.1 Table of Contents

2.2 Equations of Motion (10 degrees of freedom)

The equations of motion of the sprung and unsprung masses are presented below:

$$(\Sigma M)\,\dot{u} + \gamma_2\,\dot{q} = (\Sigma M)\,(vr - wq - g \sin\theta) + \gamma_1\,(q^2 + r^2)$$

$$- \gamma_2\,pr - \gamma_6\,q + \Sigma F_{xu} + \Sigma F_{xs} \tag{1}$$

$$(\Sigma M)\,\dot{v} - \gamma_2\,\dot{p} + \gamma_1\,\dot{r} = (\Sigma M)\,(wp - ur + g \cos\theta \sin\phi)$$

$$- \gamma_1\,pq - \gamma_2\,qr + \gamma_6\,p + \Sigma F_{yu} + \Sigma F_{ys} \tag{2}$$

$$M_s\,\dot{w} = M_s\,(uq - vp + g \cos\theta \cos\phi) - \sum_{i=1}^{4} S_i + \Sigma F_{zs} \tag{3}$$

$$- \gamma_3\,\dot{v} + (I_x + I'_x\,\dot{p} - (I_{xz}\ I'_{xz}\,\dot{r}$$

$$= \gamma_3\,(ur - wp - g \cos\theta \sin\phi) + (I_{xz} + I'_{xz})\,pq$$

$$- \gamma_4\,(p^2 + r^2) + (I_y - I_z + I'_x)\,qr - \gamma_7\,p + \Sigma N_{\phi u} + \Sigma N_{\phi s} \tag{4}$$

$$\gamma_2\,\dot{u} + (I_y + I'_y)\,\dot{q} - \gamma_4\,\dot{r} = \gamma_2\,(vr - wq - g \sin\theta)$$

$$+ I_{xz}\,(r^2 - p^2) + (I_z - I_x - I'_y)\,pr - \gamma_4\,pq$$

$$- \gamma_7\,q + I'_{xz}\,(q^2 + r^2) + \Sigma N_{\theta u} + \Sigma N_{\theta s} \tag{5}$$

$$\gamma_1\,\dot{v} - (I_{xz} + I'_{xz})\,\dot{p} - \gamma_4\,\dot{q} + (I_z + I'_z + I_F + I_R)\,\dot{r}$$

$$= \gamma_1\,(wp - ur + g \cos\theta \sin\phi) + (I_x - I_y - \gamma_5)\,pq$$

$$- (I_{xz} + I'_{xz})\,qr + \gamma_8\,q + \gamma_4\,pr + \gamma_9\,p + \Sigma N_{\psi u} + \Sigma N_{\psi s} \tag{6-E}$$

$$\gamma_1 \dot{v} - (I_{xz} + I'_{xz}) \dot{p} - \gamma_4 \dot{q} + (I_z + I'_z + I_R) \dot{r}$$

$$= \gamma_1 (wp - ur + g \cos\theta \sin\phi) + (I_x - I_y - \gamma_5) pq$$

$$- (I_{xz} + I'_{xz}) qr + \gamma_8 q + \gamma_4 pr + \gamma_9 p + \Sigma N_{\psi u} + \Sigma N_{\psi s} \qquad (6\text{-F})$$

$$\gamma_1 \dot{v} - (I_{xz} + I'_{xz}) \dot{p} - \gamma_4 \dot{q} + (I_z + I'_z) \dot{r}$$

$$= \gamma_1 (wp - ur + g \cos\theta \sin\phi) + (I_x - I_y - \gamma_5) pq$$

$$- (I_{xz} + I'_{xz}) qr + \gamma_8 q + \gamma_4 pr + \gamma_9 p + \Sigma N_{\psi u} + \Sigma N_{\psi s} \qquad (6\text{-G})$$

$$M_{uF} \dot{w} - a M_{uF} \dot{q} + M_{uF} \ddot{\delta}_F = M_{uF} [uq - vp - apr$$

$$+ (z_F + \delta_F)(p^2 + q^2) + g \cos\theta \cos\phi]$$

$$+ F_{zu1} + F_{zu2} + S_1 + S_2 \qquad (7\text{-A})$$

$$M_{uR} \dot{w} + bM_{uR} \dot{q} + M_{uR} \ddot{\delta}_R = M_{uR} [uq - vp + bpr$$

$$+ (z_R + \delta_R)(p^2 + q^2) + g \cos\theta \cos\phi]$$

$$+ F_{zu3} + F_{zu4} + S_3 + S_4 \qquad (8\text{-B})$$

$$I_F \dot{p} + I_F \ddot{\phi}_F = - I_F \phi_F (r^2 - q^2) - I_F qr + \Sigma N_{\phi F} \qquad (9\text{-A})$$

$$I_R \dot{p} + I_R \ddot{\phi}_R = - I_R \phi_R (r^2 - q^2) - I_R qr + \Sigma N_{\phi R} \qquad (10\text{-B})$$

$$\frac{M_{uF}}{2} \dot{w} + \frac{M_{uF} T_F}{4} \dot{p} - \frac{M_{uF} a}{2} \dot{q} + \frac{M_{uF}}{2} \ddot{\delta}_1$$

$$= \frac{M_{uF}}{2} [uq - vp - apr - \frac{T_F}{2} qr + (z_F + \delta_1)(p^2 + q^2)$$

$$+ g \cos\theta \cos\phi] + F_{zu1} + S_1 - F_{yu1} \tan \left(\frac{2H_{FC}}{T_F} \right) \qquad (11\text{-C})$$

$$\frac{M_{uF}}{2} \dot{w} - \frac{M_{uF} T_F}{4} \dot{p} - \frac{M_{uF} a}{2} \dot{q} + \frac{M_{uF}}{2} \ddot{\delta}_2$$

$$= \frac{M_{uF}}{2} [uq - vp - apr + \frac{T_F}{2} qr + (z_F + \delta_2) (p^2 + q^2)$$

$$+ g \cos \theta \cos \phi] + F_{zu2} + S_2 + F_{yu2} \tan \frac{2H_{FC}}{T_F} \tag{12-C}$$

$$\frac{M_{uR}}{2} \dot{w} + \frac{M_{uR} T_R}{4} \dot{p} + \frac{M_{uR} b}{2} \dot{q} + \frac{M_{uR}}{2} \ddot{\delta}_3$$

$$= \frac{M_{uR}}{2} [uq - vp + bpr - \frac{T_R}{2} qr + (z_R + \delta_3) (p^2 + q^2)$$

$$+ g \cos \theta \cos \phi] + F_{zu3} + S_3 - F_{yu3} \tan \frac{2H_{RC}}{T_R} \tag{13-D}$$

$$\frac{M_{uR}}{2} \dot{w} - \frac{M_{uR} T_R}{4} \dot{p} + \frac{M_{uR} b}{2} \dot{q} + \frac{M_{uR}}{2} \ddot{\delta}_4$$

$$= \frac{M_{uR}}{2} [uq - vp + bpr + \frac{T_R}{2} qr + (z_R + \delta_4) (p^2 + q^2)$$

$$+ g \cos \theta \cos \phi] + F_{zu4} + S_4 + F_{yu4} \tan \frac{2H_{RC}}{T_R} \tag{14-D}$$

where

$$\Sigma M = M_s + M_{uF} + M_{uR} \tag{15}$$

$$I'_x = I'_y = M_{uF} (z_F + \delta_F)^2 + M_{uR} (z_R + \delta_R)^2 \tag{16-E}$$

$$I'_x = I'_y = \frac{M_{uF}}{2} [(z_F + \delta_1)^2 + (z_F + \delta_2)^2] + M_{uR} (z_R + \delta_R)^2 \tag{16-F}$$

$$I'_x = I'_y = \frac{M_{uF}}{2} [(z_F + \delta_1)^2 + (z_F + \delta_2)^2] + \frac{M_{uR}}{2} [(z_R + \delta_3)^2 + (z_R + \delta_4)^2] \qquad (16\text{-G})$$

$$I'_z = M_{uF}\, a^2 + M_{uR}\, b^2 \qquad (17\text{-E})$$

$$I'_z = M_{uF} \left[a^2 + \left(\frac{T_F}{2}\right)^2\right] + M_{uR}\, b^2 \qquad (17\text{-F})$$

$$I'_z = M_{uF} \left[a^2 + \left(\frac{T_F}{2}\right)^2\right] + M_{uR} \left[b^2 + \left(\frac{T_R}{2}\right)^2\right] \qquad (17\text{-G})$$

$$I'_{xz} = M_{uF}\, a\, (z_F + \delta_F) - M_{uR}\, b\, (z_R + \delta_R) \qquad (18\text{-E})$$

$$I'_{xz} = \frac{M_{uF}}{2} [a\, (z_F + \delta_1) + a\, (z_F + \delta_2)] - M_{uR}\, b\, (z_R + \delta_R) \qquad (18\text{-F})$$

$$I'_{xz} = \frac{M_{uF}}{2} [a\, (z_F + \delta_1) + a\, (z_F + \delta_2)] - \frac{M_{uR}}{2} [b\, (z_R + \delta_3) + b(z_R + \delta_4) \qquad (18\text{-G})$$

$$\gamma_1 = a\, M_{uF} - b\, M_{uR} \qquad (19)$$

$$\gamma_2 = \gamma_3 = M_{uF}\, (z_F + \delta_F) + M_{uR}\, (z_R + \delta_R) \qquad (20\text{-E})$$

$$\gamma_2 = \gamma_3 = M_{uF} \left[z_F + \left(\frac{\delta_1 + \delta_2}{2}\right)\right] + M_{uR}\, (z_R + \delta_R) \qquad (20\text{-F})$$

$$\gamma_2 = \gamma_3 = M_{uF} \left[z_F + \left(\frac{\delta_1 + \delta_2}{2}\right)\right] + M_{uR} \left[z_R + \left(\frac{\delta_3 + \delta_4}{2}\right)\right] \qquad (20\text{-G})$$

$$\gamma_4 = 0 \tag{21-E}$$

$$\gamma_4 = \frac{M_{uF}\ T_F}{4} (\delta_1 - \delta_2) \tag{21-F}$$

$$\gamma_4 = \frac{M_{uF}\ T_F}{4} (\delta_1 - \delta_2) + \frac{M_{uR}\ T_R}{4} (\delta_3 - \delta_4) \tag{21-G}$$

$$\gamma_5 = M_{uF}\ a^2 + M_{uR}\ b^2 \tag{22-E}$$

$$\gamma_5 = M_{uF}\ [a^2 - \left(\frac{T_F}{2}\right)^2] + M_{uR}\ b^2 \tag{22-F}$$

$$\gamma_5 = M_{uF}\ [a^2 - \left(\frac{T_F}{2}\right)^2] + M_{uR}\ [b^2 - \left(\frac{T_R}{2}\right)^2] \tag{22-G}$$

$$\gamma_6 = 2M_{uF}\ \dot{\delta}_F + 2\ M_{uR}\ \dot{\delta}_R \tag{23-E}$$

$$\gamma_6 = M_{uF}\ (\dot{\delta}_1 + \dot{\delta}_2) + 2\ M_{uR}\ \dot{\delta}_R \tag{23-F}$$

$$\gamma_6 = M_{uF}\ (\dot{\delta}_1 + \dot{\delta}_2) + M_{uR}\ (\dot{\delta}_3 + \dot{\delta}_4) \tag{23-G}$$

$$\gamma_7 = 2M_{uF}\ (z_F + \delta_F)\ \dot{\delta}_F + 2M_{uR}\ (z_R + \delta_R)\ \dot{\delta}_R \tag{24-E}$$

$$\gamma_7 = M_{uF}\ [z_F\ (\dot{\delta}_1 + \dot{\delta}_2) + \delta_1\dot{\delta}_1 + \delta_2\dot{\delta}_2] + 2M_{uR}\ (z_R + \delta_R)\ \dot{\delta}_R \tag{24-F}$$

$$\begin{aligned}\gamma_7 = {} & M_{uF}\ [z_F\ (\dot{\delta}_1 + \dot{\delta}_2) + \delta_1\dot{\delta}_1 + \delta_2\dot{\delta}_2] \\ & + M_{uR}\ [z_R\ (\dot{\delta}_3 + \dot{\delta}_4) + \delta_3\dot{\delta}_3 + \delta_4\dot{\delta}_4]\end{aligned} \tag{24-G}$$

$$\gamma_8 = 0 \qquad (25\text{-E})$$

$$\gamma_8 = \frac{M_{uF}\ T_F}{2} (\dot{\delta}_1 - \dot{\delta}_2) \qquad (25\text{-F})$$

$$\gamma_8 = \frac{M_{uF}\ T_F}{2} (\dot{\delta}_1 - \dot{\delta}_2) + \frac{M_{uR}\ T_R}{2} (\dot{\delta}_3 - \dot{\delta}_4) \qquad (25\text{-G})$$

$$\gamma_9 = 2M_{uF}a\ \dot{\delta}_F - 2M_{uR}b\ \dot{\delta}_R \qquad (26\text{-E})$$

$$\gamma_9 = M_{uF}a\ (\dot{\delta}_1 + \dot{\delta}_2) - 2M_{uR}b\ \dot{\delta}_R \qquad (26\text{-F})$$

$$\gamma_9 = M_{uF}a\ (\dot{\delta}_1 + \dot{\delta}_2) - M_{uR}b\ (\dot{\delta}_3 + \dot{\delta}_4) \qquad (26\text{-G})$$

2.3 Vehicle Attitude and Position

The Euler angles and X, Y, and Z coordinates in fixed space of the sprung mass are computed by the following equations:

$$\phi = \int_0^t [p + (q \sin \phi + r \cos \phi) \tan \theta]\ dt + \phi_{(0)} \qquad (27)$$

$$\theta = \int_0^t (q \cos \phi - r \sin \phi)\ dt + \theta_{(0)} \qquad (28)$$

$$\psi = \int_0^t [q \sin \phi + r \cos \phi) \sec \theta] \, dt + \psi_{(0)} \tag{29}$$

Let a_{ij} be the elements of the 3×3 transformation matrix [A], from the coordinate system fixed in the vehicle sprung mass to the inertial coordinate system according to the rotational sequence ψ, θ, ϕ.

$$a_{11} = \cos \theta \cos \psi \tag{30}$$

$$a_{12} = - \cos \phi \sin \psi + \sin \phi \sin \theta \cos \psi \tag{31}$$

$$a_{13} = \sin \phi \sin \psi + \cos \phi \sin \theta \cos \psi \tag{32}$$

$$a_{21} = \cos \theta \sin \psi \tag{33}$$

$$a_{22} = \cos \phi \cos \psi + \sin \phi \sin \theta \sin \psi \tag{34}$$

$$a_{23} = - \cos \psi \sin \phi + \cos \phi \sin \theta \sin \psi \tag{35}$$

$$a_{31} = - \sin \theta \tag{36}$$

$$a_{32} = \cos \theta \sin \phi \tag{37}$$

$$a_{33} = \cos \theta \cos \phi \tag{38}$$

The position of the sprung mass in inertial space is

$$X = \int_0^t (a_{11} u + a_{12} v + a_{13} w) \, dt + X_{(0)} \tag{39}$$

$$Y = \int_0^t (a_{21}\, u + a_{22}\, v + a_{23}\, w)\, dt + Y_{(0)} \tag{40}$$

$$Z = \int_0^t (a_{31}\, u + a_{32}\, v + a_{33}\, w)\, dt + Z_{(0)} \tag{41}$$

2.4 Suspension Force

The suspension force includes the following effects: weight component, coulomb friction, spring force, shock absorber viscous damping, auxiliary roll stiffness, and antipitch and antiroll forces.

2.4.1 Solid Front Axle. The suspension force effective at the front spring location can be expressed as

$$\begin{aligned} S_i = {} & F_{sWF} - F_{1Fi} - F_{2Fi} - F_{3Fi} \\ & + F_{4Fi} + F_{APFi} + F_{ARFi} \end{aligned} \tag{42}$$

with i = 1, 2

where the individual contributions are as follows:

Static component of the sprung mass weight:

$$F_{sWF} = \frac{b}{2(a + b)}\, M_s g \tag{43}$$

Coulomb friction:

$$F_{1Fi} = C'_{Fi}\, \text{sgn}\, \dot{\zeta}_i \tag{44}$$

Suspension force due to spring deflection and suspension bump-stop impact:

$$F_{2Fi} = K_{Fi}\ \zeta_i + F_{BSi} \tag{45}$$

and

$$F_{BSi} = F(\zeta_{Si}), \tag{46}$$

where $F(\zeta_{Si})$ is a digital function that is the difference between the linear analog value and the actual front spring characteristic.

The suspension deflection measured at the spring location from the position of static equilibrium at no-load condition is

$$\zeta_{Si} = \zeta_i + \zeta_{FIN}\ . \tag{47}$$

Viscous damping force:

$$F_{3Fi} = K_{Si}\ \dot{\zeta}_i + F_{SABSi} \tag{48}$$

and

$$F_{SABSi} = F\ (\dot{\zeta}_i)\ , \tag{49}$$

where $F(\dot{\zeta}_i)$ is a digital function that is the difference between the linear analog value and the actual front shock absorber characteristic.

Suspension force due to auxiliary roll stiffness:

$$F_{4Fi} = (-1)^i\ \frac{R_F \phi_F}{T_{SF}} \tag{50}$$

Antipitch force:

$$F_{APFi} = (P_{FO} + P_{F1}\,\zeta_i' + P_{F2}\,\zeta_i'^2)\,F_{xui} \tag{51}$$

Antiroll force:

$$F_{ARFi} = (-1)^i\,(R_{FO} + R_{F1}\,\zeta_i' + R_{F2}\,\zeta_i'^2)\,F_{yui} \tag{52}$$

For these expressions, the suspension deflections relative to the vehicle from the position of static equilibrium, measured at the right (i = 1) and left (i = 2) spring locations of the front axle, respectively, are evaluated as

$$\zeta_i = \delta_F - (-1)^i\,\frac{T_{SF}}{2}\,\phi_F \tag{53}$$

and

$$\dot{\zeta}_i = \dot{\delta}_F - (-1)^i\,\frac{T_{SF}}{2}\,\dot{\phi}_F\ , \tag{54}$$

while the suspension deflection of the center of the front wheel of the front axle is

$$\zeta_i' = \delta_F - (-1)^i\,\frac{T_F}{2}\,\phi_F \tag{55}$$

or

$$\zeta_i' = \zeta_i + (-1)^i\,\frac{T_{SF} - T_F}{2}\,\phi_F\ . \tag{56}$$

2.4.2 Solid Rear Axle. For the rear suspension, the suspension force effective at the rear spring location can be written as

$$S_i = F_{sWR} - F_{1Ri} - F_{2Ri} - F_{3Ri} + F_{4Ri} + F_{APRi} + F_{ARRi} \tag{57}$$

with i = 3, 4,.

where the individual contributions are as follows:

Static component of the sprung mass weight:

$$F_{sWR} = \frac{a}{2(a + b)} M_s g \tag{58}$$

Coulomb friction:

$$F_{1Ri} = C'_{Ri} \operatorname{sgn} \dot{\zeta}_i \tag{59}$$

Suspension force due to spring deflection and suspension bump-stop impact is

$$F_{2Ri} = K_{Ri} \zeta_i + F_{BSi} \tag{60}$$

and

$$F_{BSi} = F(\zeta_{Si}) , \tag{61}$$

where $F(\zeta_{Si})$ is a digital function that is the difference between the linear analog value and the actual rear spring characteristic.

The suspension deflection measured at the spring location from the position of static equilibrium at no-load condition is

$$\zeta_{Si} = \zeta_i + \zeta_{RIN} . \tag{62}$$

Viscous damping force:

$$F_{3Ri} = K_{si} \dot{\zeta}_i + F_{SABSi} \tag{63}$$

and

$$F_{SABSi} = F(\dot{\zeta}_i) \ , \tag{64}$$

where $F(\dot{\zeta}_i)$ is a digital function that is the difference between the linear analog value and the actual rear shock absorber characteristic.

Suspension force due to auxiliary roll stiffness:

$$F_{4Ri} = (-1)^i \frac{R_R \phi_R}{T_{SR}} \tag{65}$$

Antipitch force:

$$F_{APRi} = (P_{RO} + P_{R1} \zeta_i' + P_{R2} \zeta_i'^2) F_{xui} \tag{66}$$

Antiroll force:

$$F_{ARRi} = (-1)^i (R_{RO} + R_{R1} \zeta_i' + R_{R2} \zeta_i'^2) F_{yui} \tag{67}$$

For these expressions, the suspension deflections relative to the vehicle from the position of static equilibrium, measured at the right (i = 3) and left (i = 4) spring locations of the rear axle, respectively, are evaluated as

$$\zeta_i = \delta_R - (-1)^i \frac{T_{SR}}{2} \phi_R \tag{68}$$

and

$$\dot{\zeta}_i = \dot{\delta}_R - (-1)^i \frac{T_{SR}}{2} \dot{\phi}_R \ , \tag{69}$$

while the suspension deflection of the center of the rear wheel of the rear axle is

$$\zeta_i' = \delta_R - (-1)^i \frac{T_R}{2} \phi_R \tag{70}$$

or

$$\zeta_i' = \zeta_i + (-1)^i \frac{T_{SR} - T_R}{2} \phi_R \ . \tag{71}$$

2.4.3 Independent Front Suspension. The suspension forces S_i are effective at wheel i:

$$S_i = F_{sWF} - F_{1Fi} - F_{2Fi} - F_{3Fi} + F_{4Fi} + F_{APFi} + F_{ARFi} \tag{72}$$

with i = 1, 2.

Static component of the sprung mass weight:

$$F_{sWF} = \frac{b}{2(a + b)} M_s g \tag{73}$$

Coulomb friction:

$$F_{1Fi} = C_{Fi}' \operatorname{sgn} \dot{\delta}_i \tag{74}$$

The suspension force F_{2Fi} produced by deflection of the spring is

$$F_{2Fi} = K_{Fi} \delta_i + F_{BSi} \tag{75}$$

and

$$F_{BSi} = F(\delta_{Si}) \ , \tag{76}$$

where $F(\delta_{Si})$ is a digital function that is the difference between the linear analog value and the actual spring characteristic.

δ_{Si} denotes the suspension deflection from the position of static equilibrium at no-load condition as

$$\delta_{Si} = \delta_i + \delta_{FIN} \tag{77}$$

Viscous damping force:

$$F_{3Fi} = K_{Si} \dot{\zeta}_i + F_{SABSi} \tag{78}$$

and

$$F_{SABSi} = F(\dot{\zeta}_i) \ , \tag{79}$$

where $F(\dot{\zeta}_i)$ is a digital function that is the difference between the linear analog value and the actual front shock absorber characteristic.

Suspension force due to auxiliary roll stiffness:

$$F_{4Fi} = (-1)^i \frac{R_F (\delta_1 - \delta_2)}{T_F^2} \tag{80}$$

Antipitch force:

$$F_{APFi} = (P_{FO} + P_{F1} \delta_i + P_{F2} \delta_i^2) F_{xui} \ , \tag{81}$$

where F_{xui} is the component of the tire force on wheel i in the x direction in the vehicle axis system.

Antiroll force:

$$F_{ARFi} = (-1)^i (R_{FO} + R_{F1} \delta_i + R_{F2} \delta_i^2) F_{yui} \ , \tag{82}$$

where F_{yui} is the component of the tire force on wheel i along the vehicle y axis.

2.4.4 Independent Rear Suspension. Similarly, the suspension force effective at wheel i can be expressed as

$$S_i = F_{sWR} - F_{1Ri} - F_{2Ri} - F_{3Ri} + F_{4Ri} + F_{APRi} + F_{ARRi} \tag{83}$$

with i = 3, 4,

where the individual contributions are as follows:

Static component of the sprung mass weight:

$$F_{sWR} = \frac{a}{2(a + b)} M_s g \tag{84}$$

Coulomb friction:

$$F_{1Ri} = C'_{Ri} \operatorname{sgn} \dot{\delta}_i \tag{85}$$

Suspension force due to spring deflection and suspension bump-stop impact is

$$F_{2Ri} = K_{Ri} \delta_i + F_{BSi} \tag{86}$$

and

$$F_{BSi} = F(\delta_{Si}) , \tag{87}$$

where $F(\delta_{Si})$ is a digital function that is the difference between the linear analog value and the actual rear spring characteristic.

δ_{Si} denotes the suspension deflection from the position of static equilibrium at no-load condition as

$$\delta_{Si} = \delta_i + \delta_{RIN} . \tag{88}$$

Viscous damping force:

$$F_{3Ri} = K_{Si} \dot{\zeta}_i + F_{SABSi} \tag{89}$$

and

$$F_{SABSi} = F(\dot{\zeta}_i) \quad , \tag{90}$$

where $F(\dot{\zeta}_i)$ is a digital function that is the difference between the linear analog value and the actual rear shock sbsorber characteristic.

Suspension force due to auxiliary roll stiffness:

$$F_{4Ri} = (-1)^i \frac{R_R (\delta_3 - \delta_4)}{T_R^{\ 2}} \tag{91}$$

Antipitch force:

$$F_{APRi} = (P_{RO} + P_{R1} \delta_i + P_{R2} \delta_i^{\ 2}) F_{xui} \tag{92}$$

Antiroll force:

$$F_{ARRi} = (-1)^i (R_{RO} + R_{R1} \delta_i R_{R2} \delta_i^{\ 2}) F_{yui} \tag{93}$$

2.5 Wheel Orientations

The orientations of the wheels with respect to the sprung mass are defined by the following equations:

Camber angles at wheel i:

$$\phi_1 = \phi_F + \Delta\phi_1 \tag{94-A}$$

$$\phi_2 = \phi_F + \Delta\phi_2 \tag{95-A}$$

$$\phi_3 = \phi_R \tag{96-B}$$

$$\phi_4 = \phi_R \tag{97-B}$$

$$\phi_1 = \sum_{i=0}^{5} C_{i_F} \delta_{S1}^{i} + \Delta\phi_1 \operatorname{sgn} F_{S1} - \phi_{SA1} (1 - \cos \psi_1)$$

$$+ K_{OTF} M_{XF1} \tag{94-C}$$

$$\phi_2 = - \sum_{i=0}^{5} C_{iF} \delta_{S2}^{i} + \Delta\phi_2 \operatorname{sgn} F_{S2} - \phi_{SA2} (1 - \cos \psi_2)$$

$$+ K_{OTF} M_{XF2} \tag{95-C}$$

$$\phi_3 = \sum_{i=0}^{5} C_{iR} \delta_{S3}^{i} + K_{OTR} M_{XR3} \tag{96-D}$$

$$\phi_4 = - \sum_{i=0}^{5} C_{iR} \delta_{S4}^{i} + K_{OTR} M_{XR4} \tag{97-D}$$

Steer angles at wheel i:

$$\psi_1 = \delta_{FW1} - K_{FS} \phi_F + \Delta\psi_1 \tag{98-A}$$

$$\psi_2 = \delta_{FW2} - K_{FS}\ \phi_F + \Delta\psi_2 \tag{99-A}$$

$$\psi_3 = K_{RS}\ \phi_R + K_{SR}\ M_{ZR3} + K_{LR}\ F_{S3} \tag{100-B}$$

$$\psi_4 = K_{RS}\ \phi_R + K_{SR}\ M_{ZR4} + K_{LR}\ F_{S4} \tag{101-B}$$

$$\psi_1 = \delta_{FW1} + \sum_{i=0}^{5} D_{iF}\ \delta_{S1}^{i} + \Delta\psi_1 \tag{98-C}$$

$$\psi_2 = \delta_{FW2} - \sum_{i=0}^{5} D_{iF}\ \delta_{S2}^{i} + \Delta\psi_2 \tag{99-C}$$

$$\psi_3 = \sum_{i=0}^{5} D_{iR}\ \delta_{S3}^{i} + K_{SR}\ M_{ZR3} + K_{LR}\ F_{S3} \tag{100-D}$$

$$\psi_4 = - \sum_{i=0}^{5} D_{iR}\ \delta_{S4}^{i} + K_{SR}\ M_{ZR4} + K_{LR}\ F_{S4} \tag{101-D}$$

Caster angles of the front wheels:

$$\theta_{S1} = \sum_{i=0}^{5} E_{iF}\ \delta_{S1}^{i} + \Delta\theta_1 \tag{102}$$

$$\theta_{S2} = \sum_{i=0}^{5} E_{iF} \delta_{S2}^{i} + \Delta\theta_2 \tag{103}$$

2.6 Resultant Forces and Moments

The resultant tire and aerodynamic forces and moments required for the equations of motion are given below:

Tire forces:

$$F_{xui} = F_{Rxui} + F_{Cxui} + F_{Sxui} \tag{104}$$

$$F_{yui} = F_{Ryui} + F_{Cyui} + F_{Syui} \tag{105}$$

$$F_{zui} = F_{Rzui} + F_{Czui} + F_{Szui} \tag{106}$$

where

$$F_{Rxui} = -F_{Ri} a_{31} \tag{107}$$

$$F_{Ryui} = -F_{Ri} a_{32} \tag{108}$$

$$F_{Rzui} = -F_{Ri} a_{33} \tag{109}$$

and

F_{Ri} is the tire force normal to the ground.

Furthermore:

$$F_{Cxui} = F_{Ci} (a_{11} \cos \alpha_{ci} + a_{21} \cos \beta_{ci}) \tag{110}$$

$$F_{Cyui} = F_{Ci} (a_{12} \cos \alpha_{ci} + a_{22} \cos \beta_{ci}) \tag{111}$$

$$F_{Czui} = F_{Ci} (a_{13} \cos \alpha_{ci} + a_{23} \cos \beta_{ci}) \tag{112}$$

$$F_{Sxui} = F_{Si}\ (-a_{11} \cos \beta_{ci} + a_{21} \cos \alpha_{ci}) \tag{113}$$

$$F_{Syui} = F_{Si}\ (-a_{12} \cos \beta_{ci} + a_{22} \cos \alpha_{ci}) \tag{114}$$

$$F_{Szui} = F_{Si}\ (-a_{13} \cos \beta_{ci} + a_{23} \cos \alpha_{ci}) \tag{115}$$

Furthermore:

$$\cos \alpha_{ywi} = a_{11}\ (-\sin \psi_i) + a_{12}\ (\cos \phi_i \cos \psi_i) + a_{13}\ (\sin \phi_i \cos \psi_i) \tag{116}$$

$$\cos \beta_{ywi} = a_{21}\ (-\sin \psi_i) + a_{22}\ (\cos \phi_i \cos \psi_i) + a_{23}\ (\sin \phi_i \cos \psi_i) \tag{117}$$

$$\cos \gamma_{ywi} = a_{31}\ (-\sin \psi_i) + a_{32}\ (\cos \phi_i \cos \psi_i) + a_{33}\ (\sin \phi_i \cos \psi_i) \tag{118}$$

and

$$\cos \alpha_{Ci} = \frac{\cos \beta_{ywi}}{\sqrt{\cos^2 \beta_{ywi} + \cos^2 \alpha_{ywi}}} \tag{119}$$

$$\cos \beta_{ci} = \frac{-\cos \alpha_{ywi}}{\sqrt{\cos^2 \beta_{ywi} + \cos^2 \alpha_{ywi}}} \tag{120}$$

$$\Sigma F_{xu} = \sum_{i=1}^{4} F_{xui} \tag{121}$$

$$\Sigma F_{yu} = \sum_{i=1}^{4} F_{yui} \tag{122}$$

$$\Sigma F_{zu} = \sum_{i=1}^{4} F_{zui} \tag{123}$$

Aerodynamic forces:

Cross-wind disturbance:

$$u_r = u - v_{yw} \sin \psi \tag{124}$$

$$v_r = v - v_{yw} \cos \psi \tag{125}$$

$$w_r = w \tag{126}$$

$$\bar{p} = (p - \omega_{xw} \cos \psi + \omega_{zw} \theta) \frac{\ell}{u_r} \tag{127}$$

$$\bar{q} = (q + \omega_{xw} \sin \psi - \omega_{zw} \phi) \frac{\ell}{u_r} \tag{128}$$

$$\bar{r} = (r - \omega_{zw}) \frac{\ell}{u_r} \tag{129}$$

$$V_{CW} = \sqrt{u_r^2 + v_r^2 + w_r^2} \tag{130}$$

$$\alpha = \tan^{-1}\left(\frac{w_r}{u_r}\right) \tag{131}$$

$$\tau = \left|\sin^{-1}\left(\frac{V_r}{V_{CW}}\right)\right| \quad -3.14 \leq \tau \leq 3.14 \tag{132}$$

$$q_a = \frac{1}{2}\,\rho_a\,V_{CW}^{\;2} \tag{133}$$

$$\Sigma\, F_{xs} = (C_X + \Delta C_X)\; q_a\; S_f \tag{134}$$

$$\Sigma\, F_{ys} = (C_Y + C_{y_p}\;\overline{p} + C_{y_r}\;\overline{r})\; q_a\; S_f \tag{135}$$

$$\Sigma\, F_{zs} = (C_Z + C_{z_\alpha}\;\alpha + C_{z_q}\;\overline{q})\; q_a\; S_f \tag{136}$$

Tire moments:

$$\begin{aligned}\Sigma\, N_{\phi u} = {} & (S_2 - S_1)\,\frac{T_{SF}}{2} + (S_4 - S_3)\,\frac{T_{SR}}{2} \\ & - (F_{yu1} + F_{yu2})\;(z_F + \delta_F) \\ & - (F_{yu3} + F_{yu4})\;(z_R + \delta_R)\end{aligned} \tag{137-E}$$

$$\begin{aligned}\Sigma\, N_{\phi u} = {} & (S_2 - S_1)\,\frac{T_F}{2} + (S_4 - S_3)\,\frac{T_{SR}}{2} \\ & - F_{yu1}\;(z_F + \delta_1 + h_1\,\cos\,\gamma_{h1} - H_{FC}) \\ & - F_{yu2}\;(z_F + \delta_2 + h_2\,\cos\,\gamma_{h2} - H_{FC}) \\ & - (F_{yu3} + F_{yu4})\;(z_R + \delta_R) + \sum_{i=1}^{2} M_{XFi}\end{aligned} \tag{137-F}$$

$$\Sigma N_{\phi u} = (S_2 - S_1)\frac{T_F}{2} + (S_4 - S_3)\frac{T_R}{2}$$

$$- F_{yu1}(z_F + \delta_1 + h_1 \cos \gamma_{h1} - H_{FC})$$

$$- F_{yu2}(z_F + \delta_2 + h_2 \cos \gamma_{h2} - H_{FC})$$

$$- F_{yu3}(z_R + \delta_3 + h_3 \cos \gamma_{h3} - H_{RC})$$

$$- F_{yu4}(z_R + \delta_4 + h_4 \cos \gamma_{h4} - H_{RC})$$

$$+ \sum_{i=1}^{2} M_{XFi} + \sum_{i=3}^{4} M_{XRi} \tag{137-G}$$

$$\Sigma N_{\theta u} = (S_1 + S_2)a - (S_3 + S_4)b$$

$$+ F_{xu1}(z_F + \delta_F + \frac{T_F}{2}\phi_F + h_1 \cos \gamma_{h1})$$

$$+ F_{xu2}(z_F + \delta_F - \frac{T_F}{2}\phi_F + h_2 \cos \gamma_{h2})$$

$$+ F_{xu3}(z_R + \delta_R + \frac{T_R}{2}\phi_R + h_3 \cos \gamma_{h3})$$

$$+ F_{xu4}(z_R + \delta_R - \frac{T_R}{2}\phi_R + h_4 \cos \gamma_{h4}) \tag{138-E}$$

$$\Sigma N_{\theta u} = (S_1 + S_2)a - (S_3 + S_4)b + F_{xu1}(z_F + \delta_1 + h_1 \cos \gamma_{h1})$$

$$+ F_{xu2} (z_F + \delta_2 + h_2 \cos \gamma_{h2})$$

$$+ F_{xu3} (z_R + \delta_R + \frac{T_R}{2} \phi_F + h_3 \cos \gamma_{h3})$$

$$+ F_{xu4} (z_R + \delta_R - \frac{T_R}{2} \phi_F + h_4 \cos \gamma_{h4}) \tag{138-F}$$

$$\Sigma N_{\theta u} = (S_1 + S_2)a - (S_3 + S_4)b + F_{xu1} (z_F + \delta_1 + h_1 \cos \gamma_{h1})$$

$$+ F_{xu2} (z_F + \delta_2 + h_2 \cos \gamma_{h2}) + F_{xu3} (z_R + \delta_3 + h_3 \cos \gamma_{h3})$$

$$+ F_{xu4} (z_R + \delta_4 + h_4 \cos \gamma_{h4}) \tag{138-G}$$

$$\Sigma N_{\phi F} = F_{zu1} (\frac{T_F}{2} + h_1 \cos \beta_{h1}) - F_{zu2} (\frac{T_F}{2} - h_2 \cos \beta_{h2})$$

$$- F_{yu1} (\frac{T_F}{2} \phi_F + h_1 \cos \gamma_{h1}) - F_{yu2} (- \frac{T_F}{2} \phi_F + h_2 \cos \gamma_{h2})$$

$$+ (S_1 - S_2) \frac{T_{SF}}{2} + \sum_{i=1}^{2} M_{XFi} \tag{139-A}$$

$$\Sigma N_{\phi R} = F_{zu3} (\frac{T_R}{2} + h_3 \cos \beta_{h3}) - F_{zu4} (\frac{T_R}{2} - h_4 \cos \beta_{h4})$$

$$- F_{yu3} (\frac{T_R}{2} \phi_R + h_3 \cos \gamma_{h3}) - F_{yu4} (- \frac{T_R}{2} \phi_R + h_4 \cos \gamma_{h4})$$

$$+ (S_3 - S_4) \frac{T_{SR}}{2} + \sum_{i=3}^{4} M_{XRi} \tag{140-B}$$

$$\Sigma N_{\psi u} = F_{yu1} (a + h_1 \cos \alpha_{h1}) + F_{yu2} (a + h_2 \cos \alpha_{h2})$$

$$- F_{yu3} (b - h_3 \cos \alpha_{h3}) - F_{yu4} (b - h_4 \cos \alpha_{h4})$$

$$+ F_{xu2} (\frac{T_F}{2} - h_2 \cos \beta_{h2}) - F_{xu1} (\frac{T_F}{2} + h_1 \cos \beta_{h1})$$

$$+ F_{xu4} (\frac{T_R}{2} - h_4 \cos \beta_{h4}) - F_{xu3} (\frac{T_R}{2} + h_3 \cos \beta_{h3})$$

$$+ \sum_{i=1}^{2} M_{ZFi} + \sum_{i=3}^{4} M_{ZRi} \tag{141}$$

where

$$\cos \alpha_{hi} = a_{11} \cos \alpha_{Ri} + a_{21} \cos \beta_{Ri} + a_{31} \cos \gamma_{Ri} \tag{142}$$

$$\cos \beta_{hi} = a_{12} \cos \alpha_{Ri} + a_{22} \cos \beta_{Ri} + a_{32} \cos \gamma_{Ri} \tag{143}$$

$$\cos \gamma_{hi} = a_{13} \cos \alpha_{Ri} + a_{23} \cos \beta_{Ri} + a_{33} \cos \gamma_{Ri} \tag{144}$$

and

$$\cos \alpha_{Ri} = \frac{-\cos \gamma_{ywi} \cos \alpha_{ywi}}{\sqrt{\cos^2 \alpha_{ywi} + \cos^2 \beta_{ywi}}} \tag{145}$$

$$\cos \beta_{Ri} = \frac{-\cos \gamma_{ywi} \cos \beta_{ywi}}{\sqrt{\cos^2 \alpha_{ywi} + \cos^2 \beta_{ywi}}} \tag{146}$$

$$\cos \gamma_{Ri} = \frac{\cos^2 \alpha_{ywi} + \cos^2 \beta_{ywi}}{\sqrt{\cos^2 \alpha_{ywi} + \cos^2 \beta_{ywi}}} \tag{147}$$

Aerodynamic moments:

$$d_{CG} = a - \frac{\ell}{2} \tag{148}$$

$$C'_L = \frac{\ell_v}{\ell} C_1 + \frac{Z_{(0)}}{\ell} C_Y \tag{149}$$

$$C'_M = \frac{\ell_v}{\ell} C_M - \frac{d_{CG}}{\ell} C_Z - \frac{Z_{(0)}}{\ell} C_X \tag{150}$$

$$C'_N = \frac{\ell_v}{\ell} C_N + \frac{d_{CG}}{\ell} C_Y \tag{151}$$

$$\Sigma N_{\phi s} = (C'_L + C_{\ell_p} \bar{p} + C_{\ell_r} \bar{r}) q_a S_f \ell \tag{152}$$

$$\Sigma N_{\theta s} = (C'_M + C_{m_\alpha} \alpha + C_{m_q} \bar{q}) q_a S_f \ell \tag{153}$$

$$\Sigma N_{\psi s} = (C'_N + C_{n_p} \bar{p} + C_{n_r} \bar{r}) q_a S_f \ell \tag{154}$$

2.7 Radial Tire Force and Rolling Radius

The radial tire forces and the rolling radii of the tires are computed by the following equations:

$$F'_{Ri} = K_{Ti} (R_w - h_i) \tag{155}$$

where

$$h_i = \Delta_i \text{ for } h_i \leq R_w \tag{156}$$

$$h_i = R_w \text{ for } h_i > R_w \tag{157}$$

and

$$\Delta_i = \frac{\sqrt{\cos^2 \alpha_{ywi} + \cos^2 \beta_{ywi}}}{\cos^2 \alpha_{ywi} + \cos^2 \beta_{ywi}} (Z_{Si} - Z_i) \tag{158}$$

$$Z_1 = Z + a_{31} a + a_{32} \frac{T_F}{2} + a_{33} (z_F + \frac{T_F}{2} \phi_F + \delta_F) \tag{159-A}$$

$$Z_2 = Z + a_{31} a - a_{32} \frac{T_F}{2} + a_{33} (z_F - \frac{T_F}{2} \phi_F + \delta_F) \tag{160-A}$$

$$Z_3 = Z - a_{31} b + a_{32} \frac{T_R}{2} + a_{33} (z_R + \frac{T_R}{2} \phi_R + \delta_R) \tag{161-B}$$

$$Z_4 = Z - a_{31} b - a_{32} \frac{T_R}{2} + a_{33} (z_R - \frac{T_R}{2} \phi_R + \delta_R) \tag{162-B}$$

$$Z_1 = Z + a_{31} a + a_{32} \frac{T_F}{2} + a_{33} (z_F + \delta_1) \tag{159-C}$$

$$Z_2 = Z + a_{31} a - a_{32} \frac{T_F}{2} + a_{33} (z_F + \delta_2) \tag{160-C}$$

$$Z_3 = Z - a_{31} b + a_{32} \frac{T_R}{2} + a_{33} (z_R + \delta_3) \tag{161-D}$$

$$Z_4 = Z - a_{31} b - a_{32} \frac{T_R}{2} + a_{33} (z_R + \delta_4) \tag{162-D}$$

and the initial tire loading and orientation are as shown below:

$$\theta_{(0)} = \frac{[h_{1(0)} - h_{3(0)}] + [z_F - z_R]}{(a + b)} \tag{163}$$

$$h_{1(0)} = h_{2(0)} = R_w - \frac{g}{2K_{T1}} \left[M_{UF} + \left(\frac{b}{a + b} \right) M_S \right] \tag{164}$$

$$h_{3(0)} = h_{4(0)} = R_w - \frac{g}{2K_{T3}} \left[M_{UR} + \left(\frac{b}{a + b} \right) M_S \right] \tag{165}$$

$$Z_{(0)} = - \frac{b[h_{1(0)} + z_F] + a[h_{3(0)} + z_R]}{(a + b)} + Z_{bias} \ . \tag{166}$$

Wheel lift-off indication is provided by

$$Z_{MXi} = (R_w - h_i) \qquad i = 1, 2, 3, 4 \tag{167}$$

where

$Z_{MXi} > 0$ wheel i in contact with tire-terrain patch,

$Z_{MXi} \leq 0$ wheel i not in contact with tire-terrain patch.

2.8 Tire Circumferential Force

The circumferential tire forces for both driving and braking are defined by the following equation:

$$F_{Ci} = - \mu_i' F_{Ri} \tag{168}$$

where

$$F_{Ri} = F_{Ri}' \left(\frac{1}{\cos \phi_{cGi}}\right) - F_{Si} \tan \phi_{cGi} \ . \tag{169}$$

2.9 Circumferential Friction Coefficients

The circumferential friction coefficient equations are shown below:

$$\mu_i' = m_{2i}\,(\mathrm{SLIP})_i + \mu_{0i} \quad \text{for } (\mathrm{SLIP})_i > SI_i$$

$$= m_{1i}\,(\mathrm{SLIP})_i \quad \text{for } (\mathrm{SLIP})_i \le SI_i\,. \tag{170}$$

Computation of the slopes for the μ_i' curve is performed by the following equations:

Front wheels:

$$\mu_{SF}' = (\mu_{SF} + S_{1F}\,F_{Ri})\,|\cos(\beta_i)| \qquad i = 1, 2 \tag{171}$$

$$\mu_{PF} = P_{BF1} + P_{BF2}\,F_{Ri} \tag{172}$$

$$SN_i = (SN)_{SO}/(SN)_T \tag{173}$$

$$m_{1i} = \left(\frac{\mu_{PF}}{SI_i}\right)(1.0 - 57.3\,B_c\,|\beta_i + \beta_i'|)\,SN_i \quad \text{for } m_{1i} \ge \frac{\mu_{SF}'}{SI_i}\,SN_i$$

$$= \left(\frac{\mu_{SF}'}{SI_i}\right)SN_i \quad \text{for } m_{1i} < \frac{\mu_{SF}'}{SI_i}\,SN_i \tag{174}$$

$$m_{2i} = \left[\frac{\mu_{SF}' - \mu_{PF}\,(1.0 - 57.3\,B_c\,|\beta_i + \beta_i'|)}{(1.0 - SI_i)}\right]SN_i \quad \text{for } m_{1i} \ge \frac{\mu_{SF}'}{SI_i}\,SN_i$$

$$= 0.0 \quad \text{for } m_{1i} < \frac{\mu_{SF}'}{SI_i}\,SN_i \tag{175}$$

$$\mu_{1i} = \mu'_{SF}\ SN_i \tag{176}$$

$$\mu_{0i} = \mu_{1i} - m_{2i} \tag{177}$$

Rear wheels:

$$\mu'_{SR} = (\mu_{SR} + S_{1R}\ F_{Ri})\ \left|\cos\ (\beta_i)\right| \qquad i = 3,\ 4 \tag{178}$$

$$\mu_{PR} = P_{BR1} + P_{BR2}\ F_{Ri} \tag{179}$$

$$SN_i = (SN)_{SO}/(SN)_T \tag{180}$$

$$m_{1i} = \left(\frac{\mu_{PR}}{SI_i}\right)(1.0 - 57.3\ B_c\ \left|\beta_i + \beta'_i\right|)\ SN_i \qquad \text{for } m_{1i} \geq \frac{\mu'_{SR}}{SI_i}\ SN_i$$

$$= \left(\frac{\mu'_{SR}}{SI_i}\right)\ SN_i \qquad \text{for } m_{1i} < \frac{\mu'_{SR}}{SI_i}\ SN_i \tag{181}$$

$$m_{2i} = \left[\frac{\mu'_{SR} - \mu_{PR}\ (1.0 - 57.3\ B_c\ \left|\beta_i + \beta'_i\right|)}{(1.0 - SI_i)}\right]\ SN_i \qquad \text{for } m_{1i} \geq \frac{\mu'_{SR}}{SI_i}\ SN_i$$

$$= 0.0 \qquad \text{for } m_{1i} < \frac{\mu'_{SR}}{SI_i}\ SN_i \tag{182}$$

$$\mu_{1i} = \mu'_{SR}\ SN_i \tag{183}$$

$$\mu_{0i} = \mu_{1i} - m_{2i} \tag{184}$$

1.11 Wheel Slip

Computation of circumferential wheel slip is performed by the following equations:

$$(SLIP)_i = 1 \qquad \text{for } \xi_i > 1$$

$$= \xi_i \qquad \text{for } -1 \leq \xi_i \leq 1$$

$$= -1 \qquad \text{for } \xi_i < -1 \tag{15}$$

where

$$\xi_i = 1 - \frac{\omega_i R_i}{u_{Gi} \cos \psi_i' + v_{Gi} \sin \psi_i'} \tag{16}$$

2.11 Wheel Rotational Equations (4 degrees of freedom)

The wheel rotational equations required to compute wheel slip are presented below:

$$\left(I_{WF} + \frac{1}{4} I_{DR} \overline{AR}_F^{\,2}\right) \dot{\omega}_1 + \left(\frac{1}{4} I_{DF} \overline{AR}_F^{\,2}\right) \dot{\omega}_2 = - F_{X1} h_1 + \overline{TQ}_1 \qquad (127)$$

$$\left(I_{WF} + \frac{1}{4} I_{DF} \overline{AR}_F^{\,2}\right) \dot{\omega}_2 + \left(\frac{1}{4} I_{DF} \overline{AR}_F^{\,2}\right) \dot{\omega}_1 = - F_{X2} h_2 + \overline{TQ}_2 \qquad (128)$$

$$\left(I_{WR} + \frac{1}{4} I_{DR} \overline{AR}_R^{\,2}\right) \dot{\omega}_3 + \left(\frac{1}{4} I_{DR} \overline{AR}_R^{\,2}\right) \dot{\omega}_4 = - F_{X3} h_3 - \overline{TQ}_3 \qquad (129)$$

$$\left(I_{WR} + \frac{1}{4} I_{DR} \overline{AR}_R^{\,2}\right) \dot{\omega}_4 + \left(\frac{1}{4} I_{DR} \overline{AR}_R^{\,2}\right) \dot{\omega}_3 = - F_{X4} h_4 - \overline{TQ}_4 \qquad (130)$$

where

$$\omega_i = \omega_i(0) + \int_0^t \dot{\omega}_i \, dt \qquad (131)$$

For: $(SLIP)_i = 0$ at $t = 0$,

$$\omega_i(0) = \frac{u_{Gi}(0) \cos \psi_i'(0) + v_{Gi}(0) \sin \psi_i'(0)}{h_i(0)} \qquad (132)$$

$$\overline{TQ}_1 = (1 - \lambda_D) \left(\frac{\overline{AR}_F}{2}\right) \overline{TQ}_{DF} + \lambda_{B1} \overline{TQ}_{B1} \qquad (133)$$

$$\overline{TQ}_2 = (1 - \lambda_D) \left(\frac{\overline{AR}_F}{2}\right) \overline{TQ}_{DF} + \lambda_{B2} \overline{TQ}_{B2} \qquad (134)$$

$$\overline{TQ}_3 = \lambda_D \left(\frac{\overline{AR}_R}{2}\right) \overline{TQ}_{DR} + \lambda_{B3} \overline{TQ}_{B3} \qquad (135)$$

$$\overline{TQ}_4 = \lambda_D \left(\frac{\overline{AR}_R}{2} \right) \overline{TQ}_{DR} + \lambda_{B4} \overline{TQ}_{B4} \tag{196}$$

2.12 Brake and Drive Torques

The drive torques generated to maintain a constant velocity are computed by

$$\begin{aligned} \overline{TQ}_D &= K_{TQ} (V_C - u), \quad \text{for } \overline{TQ}_D \leq TQ_{D_{max}} \\ &= TQ_{D_{max}}, \quad \text{otherwise}, \end{aligned} \tag{197}$$

where V_C is the desired velocity.

Values of 1000 lb-in./in./s and 6000 lb-in. were assigned to K_{TQ} and $TQ_{D_{max}}$, respectively. When braking is investigated, the drive torque is 0 and the brake torque magnitudes are determined from input data functions.

$$\overline{TQ}_{B1} = \overline{TQ}_{B2} = FF(PFL), \text{ lb-in.} \tag{198}$$

$$\overline{TQ}_{B3} = \overline{TQ}_{B4} = FR(PFL), \text{ lb-in.} \tag{199}$$

where PFL is an input value for brake-line pressure.

2.13 Tire Side Force

The nonlinear tire side forces are computed using the following equations:

$$\begin{aligned} F_{Si} = F_{Ri} \Big\{ &|\mu_{yi}\, g(\overline{\beta}_i)| \qquad\qquad i = 1, 2 \\ &- \Big[|\mu_{yi}\, g(\overline{\beta}_i)| - \mu_{SF} |\sin(\beta_i)|\, SN_i \Big] F_i \Big\} \operatorname{sgn} g(\overline{\beta}_i) \end{aligned} \tag{200}$$

$$F_{Si} = F_{Ri} \left\{ \left| \mu_{yi}\, g(\overline{\beta}_i) \right| \right. \qquad i = 3, 4$$

$$\left. - \left[\left| \mu_{yi}\, g(\overline{\beta}_i) \right| - \mu_{SR} \left| \sin(\beta_i) \right| SN_i \right] F_i \right\} \operatorname{sgn} g(\overline{\beta}_i) \tag{201}$$

2.14 Tire Side Force Friction Coefficient

The side force coefficient of friction is defined below:

$$\mu_{yi} = (B_{1F}\, F_{Ri} + B_{2F}\, C_{vi} + B_{3F} + B_{4F}\, F_{Ri}^{\;2})\, SN_i \qquad i = 1, 2 \tag{202}$$

$$\mu_{yi} = (B_{1R}\, F_{Ri} + B_{2R}\, C_{vi} + B_{3R} + B_{4R}\, F_{Ri}^{\;2})\, SN_i \qquad i = 3, 4 \tag{203}$$

and

$$C_{vi} = \sqrt{u_{GI}^{\;2} + v_{Gi}^{\;2}} \quad . \tag{204}$$

2.15 Velocities of the Tire Contact Points

The velocities of the tire contact points along the vehicle axes are computed by the following equations:

$$u_1 = u - \frac{T_F}{2} r + (z_F + \delta_F + \frac{T_F}{2} \phi_F)\, q \tag{205-A}$$

$$u_2 = u + \frac{T_F}{2} r + (z_F + \delta_F - \frac{T_F}{2} \phi_F)\, q \tag{206-A}$$

$$u_3 = u - \frac{T_R}{2} r + (z_R + \delta_R + \frac{T_R}{2} \phi_R)\, q \tag{207-B}$$

$$u_4 = u + \frac{T_R}{2} r + (z_R + \delta_R - \frac{T_R}{2} \phi_R)\, q \tag{208-B}$$

$$u_1 = u - \frac{T_F}{2} r + (z_F + \delta_1)\, q \tag{205-C}$$

$$u_2 = u + \frac{T_F}{2} r + (z_F + \delta_2) q \tag{206-C}$$

$$u_3 = u - \frac{T_R}{2} r + (z_R + \delta_3) q \tag{207-D}$$

$$u_4 = u + \frac{T_R}{2} r + (z_R + \delta_4) q \tag{208-D}$$

$$v_1 = v + ar - (z_F + \delta_F)p - (\frac{T_F}{2} \phi_F + h_1 \cos \gamma_{h1})(p + \dot{\phi}_F) \tag{209-A}$$

$$v_2 = v + ar - (z_F + \delta_F)p - (- \frac{T_F}{2} \phi_F + h_2 \cos \gamma_{h2})(p + \dot{\phi}_F) \tag{210-A}$$

$$v_3 = v - br - (z_R + \delta_R)p - (\frac{T_R}{2} \phi_R + h_3 \cos \gamma_{h3})(p + \dot{\phi}_R) \tag{211-B}$$

$$v_4 = v - br - (z_R + \delta_R)p - (- \frac{T_R}{2} \phi_R + h_4 \cos \gamma_{h4})(p + \dot{\phi}_R) \tag{212-B}$$

$$v_1 = v + ar - (z_F + \delta_1 + h_1 \cos \gamma_{h1})\ p \tag{209-C}$$

$$v_2 = v + ar - (z_F + \delta_2 + h_2 \cos \gamma_{h2})\ p \tag{210-C}$$

$$v_3 = v - br - (z_R + \delta_3 + h_3 \cos \gamma_{h3})p \tag{211-D}$$

$$v_4 = v - br - (z_R + \delta_4 + h_4 \cos \gamma_{h4})p \tag{212-D}$$

$$w_1 = w + \dot{\delta}_F - aq - (- \frac{T_F}{2} - h_1 \cos \beta_{h1})(p + \dot{\phi}_F) \tag{213-A}$$

$$w_2 = w + \dot{\delta}_F - aq - (\frac{T_F}{2} - h_2 \cos \beta_{h2})(p + \dot{\phi}_F) \qquad (214\text{-A})$$

$$w_3 = w + \dot{\delta}_R + bq - (-\frac{T_R}{2} - h_3 \cos \beta_{h3})(p + \dot{\phi}_R) \qquad (215\text{-B})$$

$$w_4 = w + \dot{\delta}_R + bq - (\frac{T_R}{2} - h_4 \cos \beta_{h4})(p + \dot{\phi}_R) \qquad (216\text{-B})$$

$$w_1 = w - aq + (\frac{T_F}{2} + h_1 \cos \beta_{h1})p + \dot{\delta}_1 \qquad (213\text{-C})$$

$$w_2 = w - aq - (\frac{T_F}{2} - h_2 \cos \beta_{h2})p + \dot{\delta}_2 \qquad (214\text{-C})$$

$$w_3 = w + bq + (\frac{T_R}{2} + h_3 \cos \beta_{h3})p + \dot{\delta}_3 \qquad (215\text{-D})$$

$$w_4 = w + bq - (\frac{T_R}{2} - h_4 \cos \beta_{h4})p + \dot{\delta}_4 \ . \qquad (216\text{-D})$$

The wheel velocities in the ground plane are computed by

$$u_{Gi} = u_i \cos \theta_{XGi} - w_i \sin \theta_{XGi} \qquad (217)$$

$$v_{Gi} = v_i \cos \phi - w_i \sin \phi \qquad i = 1,2,3,4 \qquad (218)$$

where

$$\cos \theta_{XGi} = \frac{\cos \theta \cos \phi}{\sqrt{\cos^2 \phi + \sin^2 \phi \sin^2 \theta}} \qquad (219)$$

$$\sin \theta_{XGi} = \frac{-\sin \theta}{\sqrt{\cos^2 \phi + \sin^2 \phi \sin^2 \theta}} \ . \qquad (220)$$

2.16 Combined Slip Angle and Camber Shaping Function

The dimensionless side force shaping function for slip angle and camber is as follows:

$$g(\bar{\beta}_i) = \bar{\beta}_i - \frac{1}{3}\bar{\beta}_i\,|\bar{\beta}_i| + \frac{1}{27}\bar{\beta}_i^{\,3} \qquad \text{if} \quad |\bar{\beta}_i| < 3$$

$$= \frac{\bar{\beta}_i}{|\bar{\beta}_i|} \qquad \text{if} \quad |\bar{\beta}_i| \geq 3 \qquad i = 1, 2, 3, 4\,. \tag{221}$$

For $\quad F_{Ri} \leq A\Omega_{TF} A_{2F}, \qquad i = 1, 2$

$$\bar{\beta}_i = \frac{A_{1F}\,F_{Ri}\,(F_{Ri} - A_{2F}) - A_{0F}\,A_{2F}}{A_{2F}\,\mu_{yi}\,F_{Ri}}\,(\beta_i + \beta_i') \tag{222}$$

$$\beta_i' = \frac{A_{2F}\,A_{3F}\,(A_{4F} - F_{Ri})\,F_{Ri}\,\phi_{CGi}}{A_{4F}\,[A_{1F}\,F_{Ri}\,(F_{Ri} - A_{2F}) - A_{0F}\,A_{2F}]}\,. \tag{223}$$

If $\quad F_{Ri} > A\Omega_{TF}\,A_{2F}, \qquad i = 1, 2$

$$\bar{\beta}_i = \frac{A_{1F}\,A_{2F}\,A\Omega_{TF}\,(A\Omega_{TF} - 1) - A_{0F}}{\mu_{yi}\,F_{Ri}}\,(\beta_i + \beta_i') \tag{224}$$

$$\beta_i' = \frac{A_{2F}\,A_{3F}\,A\Omega_{TF}\,(A_{4F} - A\Omega_{TF}\,A_{2F})\,\phi_{CGi}}{A_{4F}\,[A_{1F}\,A_{2F}\,A\Omega_{TF}\,(A\Omega_{TF} - 1) - A_{0F}]}\,. \tag{225}$$

For $\quad F_{Ri} \leq A\Omega_{TR}\,A_{2R}, \qquad i = 3, 4$

$$\bar{\beta}_i = \frac{A_{1R}\,F_{Ri}\,(F_{Ri} - A_{2R}) - A_{0R}\,A_{2R}}{A_{2R}\,\mu_{yi}\,F_{Ri}}\,(\beta_i + \beta_i') \tag{226}$$

$$\beta_i' = \frac{A_{2R}\,A_{3R}\,(A_{4R} - F_{Ri})\,F_{Ri}\,\phi_{CGi}}{A_{4R}\,[A_{1R}\,F_{Ri}\,(F_{Ri} - A_{2R}) - A_{0R}\,A_{2R}]}\,. \tag{227}$$

If $\quad F_{Ri} > A\Omega_{TR}\, A_{2R}, \qquad i = 3, 4$

$$\bar{\beta}_i = \frac{A_{1R}\, A_{2R}\, A\Omega_{TR}\, (A\Omega_{TR} - 1) - A_{OR}}{\mu_{yi}\, F_{Ri}} (\beta_i + \beta_i') \tag{228}$$

$$\beta_i' = \frac{A_{2R}\, A_{3R}\, A\Omega_{TR}\, (A_{4R} - A\Omega_{TR}\, A_{2R})\, \phi_{CGi}}{A_{4R}[A_{1R}\, A_{2R}\, A\Omega_{TR}\, (A\Omega_{TR} - 1) - A_{OR}]} \tag{229}$$

2.17 Wheel Slip Angle

$$\beta_i = \tan^{-1}\left(\frac{v_{Gi}}{|u_{Gi}|}\right) - \psi_i' \operatorname{sgn}\left(u_{Gi}\right) \tag{230}$$

where

$$\psi_i' = \sin^{-1}\left[\frac{-(a_{11} \cos \alpha_{ywi} + a_{21} \cos \beta_{ywi})}{\cos \theta \sqrt{\cos^2 \alpha_{ywi} + \cos^2 \beta_{ywi}}}\right] \tag{231}$$

2.18 Wheel Camber with Respect to the Road

The camber angles of the wheels measured with respect to the road are given by

$$\phi_{CGi} = \sin^{-1} (\cos \gamma_{ywi}) + K_{CF}\, F_{Si} + \Delta\phi_i \qquad i = 1, 2 \qquad \text{(232-A)}$$

$$\phi_{CGi} = \sin^{-1} (\cos \gamma_{ywi}) + K_{CF}\, F_{Si} \qquad i = 1, 2 \qquad \text{(232-C)}$$

$$\phi_{CGi} = \sin^{-1} (\cos \gamma_{ywi}) + K_{CR}\, F_{Si} \qquad i = 3, 4 \qquad \text{(233-B,D)}$$

2.19 Wheel Slip Shaping Function

The dimensionless side force shaping function for circumferential slip is empirically derived.

$$F_i \left[(SLIP)_i \right] = \text{input table} \tag{234}$$

F_i	$(SLIP)_i$ (%)
0.00	00.0
0.01	05.0
0.03	10.0
0.07	15.0
0.17	20.0
0.35	30.0
0.54	40.0
0.81	60.0
0.93	80.0
1.00	100.0

2.20 Tire Moments

The tire-road reaction moments acting about the kingpins are computed by the following equations:

$$\begin{aligned} M_{Ti} = &- (y_{SAi} - h_i \phi_{SOi}) \Big[(F_{xui} - F_{zui} \theta_{Si}) \cos \psi_i \\ &+ (F_{yui} + F_{zui} \phi_{SAi}) \sin \psi_i \Big] \\ &- \overline{PT}_i \cos \psi_i \Big[(F_{yui} + F_{zui} \phi_{SAi}) \cos \psi_i \\ &- (F_{xui} - F_{zui} \theta_{si}) \sin \psi_i \Big] \qquad i = 1, 2 \end{aligned} \tag{235}$$

where

$$\phi_{SA1} = \phi_{SA01} + \sum_{i=1}^{5} C_{iF}\ \delta_{S1}^{i} \tag{236}$$

$$\phi_{SA2} = \phi_{SA02} - \sum_{i=1}^{5} C_{iF}\ -\ \delta_{S2}^{i}\ . \tag{237}$$

The tire aligning torques are defined as

$$M_{ZFi} = (A_{F1}\ F_{Ri} + A_{F2}\ |F_{Si}|)\ F_{Si} + A_{F3}\ F_{Ri}(|\phi_{CGi}|)^{\frac{1}{2}}\ \mathrm{sgn}\ \phi_{CGi} \qquad i = 1, 2 \tag{238}$$

$$M_{ZRi} = (A_{R1}\ F_{Ri} + A_{R2}\ |F_{Si}|)\ F_{Si} + A_{R3}\ F_{Ri}(|\phi_{CGi}|)^{\frac{1}{2}}\ \mathrm{sgn}\ \phi_{CGi} \qquad i = 3, 4\ . \tag{239}$$

The tire overturning moments are defined as

$$M_{XFi} = O_{F0} + (O_{F1} + O_{F2}|\phi_{CGi}|)\ F_{Si}\ F_{Ri} + O_{F3}\ \phi_{CGi}\ F_{Ri} \qquad i = 1, 2 \tag{240}$$

$$M_{XRi} = O_{R0} + (O_{R1} + O_{R2}|\phi_{CGi}|)\ F_{Si}\ F_{Ri} + O_{R3}\ \phi_{CGi}\ F_{Ri} \qquad i = 3, 4\ . \tag{241}$$

2.21 Steering Equations (3 degrees of freedom)

The steering equations are presented on the next page.

$$(\dot{r} + \ddot{\delta}_{FWi})\, I_{FW} = - H_i\, \dot{\delta}_{FWi} + M_{Ti} - M_{SSi} + M_{ZFi} \tag{242}$$

$$i = 1,\ 2$$

$$M_{CR}\, \ddot{y}_{CR} = -C_{FCR} - C_{CR}\, \dot{y}_{CR} + \frac{T_P}{a_p} + \frac{M_{SS1}}{a_{L1}} + \frac{M_{SS2}}{a_{L2}} \tag{243}$$

where $C_{FCR} = f(\dot{y}_{CR})$.

Conditions:

$$T_p = N_G \left\{ K_{SC} \left[\left(\delta_{SW} - N_G \frac{y_{CR}}{a_p} \right) - \frac{\varepsilon_{SP}}{2} \operatorname{sgn} \left(\delta_{SW} - N_G \frac{y_{CR}}{a_p} \right) \right] \right\}, \tag{244}$$

if $\left| \delta_{SW} - N_G \dfrac{y_{CR}}{a_p} \right| > \dfrac{\varepsilon_{SP}}{2}$;

otherwise $T_p = 0$. (245)

$$M_{SSi} = K_{SLi} \left[\left(\delta_{FWi} - \frac{y_{CR}}{a_{Li}} \right) - \frac{\varepsilon_{pi}}{2} \operatorname{sgn} \left(\delta_{FWi} - \frac{y_{CR}}{a_{Li}} \right) \right] \tag{246}$$

if $\left| \delta_{FWi} - \dfrac{y_{CR}}{a_{Li}} \right| > \dfrac{\varepsilon_{pi}}{2}$;

otherwise $M_{SSi} = 0$. (247)

2.22 Longitudinal and Lateral Acceleration

The longitudinal and lateral accelerations of the sprung mass are computed by the following equations:

$$A_x = (\dot{u} - vr + wq)/g \tag{248}$$

$$A_y = (\dot{v} + ru - wp)/g\ . \tag{249}$$

2.23 Dual Tires on Solid Rear Axle

2.23.1 Equations of Motion

$$M_{uR}\,\dot{w} + b\,M_{uR}\,\dot{q} + M_{uR}\,\ddot{\delta}_R$$

$$= M_{uR}\,[uq - vp + bpr + (z_R + \delta_R)(p^2 + q^2)$$

$$+ g\cos\theta\cos\phi] + 2\,(F_{zu3} + F_{zu4}) + S_3 + S_4 \qquad (250\text{-H})$$

and $$(F'_{R3} + F'_{R4}) = K_{T3}\,(R_w + Z_{3DE})$$

$$+ K_{T4}\,(R_w + Z_{4DE}) \qquad (251)$$

2.23.2 Suspension Forces

$$F_{APRi} = (P_{R0} + P_{R1}\,\zeta'_i + P_{R2}\,\zeta'^2_i)\,(F_{xui} + F_{xu(i+2)}) \qquad (252)$$

$$i = 3,\ 4$$

$$F_{ARRi} = (R_{R0} + R_{R1}\,\zeta'_i + R_{R2}\,\zeta'^2_i)\,(F_{yui} + F_{yu(i+2)}) \qquad (253)$$

$$i = 3,\ 4$$

$$\zeta'_i = \delta_R - (-1)^i \left(\frac{T_{IR} + T_{OR}}{2} \right) \phi_R \qquad (254)$$

$$i = 3,\ 4$$

2.23.3 Wheel Orientation

$$\psi_3 = K_{RS}\,\phi_R + K_{SR}\,\frac{M_{ZR3}}{2} + K_{LR}\,F_{S3} \qquad (255)$$

$$\psi_4 = K_{RS}\,\phi_R + K_{SR}\,\frac{M_{ZR4}}{2} + K_{LR}\,F_{S4} \qquad (256)$$

2.23.4 Resultant Forces and Moments

Tire forces:

$$F_{yui} = -F_{iRID}\ \phi + F_{CiID} \sin \psi_i + F_{SiID} \cos \psi_i \qquad (257)$$

$$i = 3,\ 4$$

$$F_{yui} = -F_{iROD}\ \phi + F_{CiOD} \sin \psi_{(i-2)} + F_{SiOD} \cos \psi_{(i-2)} \qquad (258)$$

$$i = 5,\ 6$$

$$F_{xui} = F_{iRID}\ \theta + F_{CiID} \cos \psi_i - F_{SiID} \sin \psi_i \qquad (259)$$

$$i = 3,\ 4$$

$$F_{xui} = F_{iROD}\ \theta + F_{CiOD} \cos \psi_{(i-2)} - F_{SiOD} \sin \psi_{(i-2)} \qquad (260)$$

$$i = 5,\ 6$$

Aligning moments:

$$M_{ZiRID} = (A_{R1}\ F_{iRID} + A_{R2}\ |F_{SiID}|)\ F_{SiId}$$

$$+ A_{R3}\ F_{iRID}\ (|\phi_{CGi}|)^{\frac{1}{2}} \qquad i = 3,\ 4 \qquad (261)$$

$$M_{ZiROD} = (A_{R1}\ F_{iROD} + A_{R2}\ |F_{SiOD}|)\ F_{SiOD}$$

$$+ A_{R3}\ F_{iROD}\ (|\phi_{CG_{(i-2)}}|)^{\frac{1}{2}} \qquad i = 5,\ 6 \qquad (262)$$

$$M_{ZRi} = M_{ZiRID} + M_{Z(i+2)ROD}$$

$$i = 3,\ 4 \qquad (263)$$

Overturning moments:

$$M_{XiRID} = (O_{R1} + O_{R2} |\phi_{CGi}|) F_{SiID} F_{iRID} + O_{R3} \phi_{CGi} F_{iRID} \qquad i = 3, 4 \tag{264}$$

$$M_{XiROD} = (O_{R1} + O_{R2} |\phi_{CG(i-2)}|) F_{SiID} F_{iRID} + O_{R3} \phi_{CG(i-2)} F_{iRID} \qquad i = 5, 6 \tag{265}$$

$$M_{XRi} = M_{XiRID} + M_{X(i+2)ROD} \qquad i = 3, 4 \tag{266}$$

Suspension and tire moments:

$$\begin{aligned}\Sigma N_{\psi u} = {} & F_{yu1} (a + h_1 \cos \alpha_{h1}) + F_{yu2} (a + h_2 \cos \alpha_{h2}) \\ & - (F_{yu3} + F_{yu5})(b - h_3 \cos \alpha_{h3}) \\ & - (F_{yu4} + F_{yu6})(b - h_4 \cos \alpha_{h4}) \\ & + F_{xu2} (\frac{T_F}{2} - h_2 \cos \beta_{h2}) - F_{xu1} (\frac{T_F}{2} + h_1 \cos \beta_{h1}) \\ & + F_{xu4} (\frac{T_{IR}}{2} - h_4 \cos \beta_{h4}) - F_{xu3} (\frac{T_{IR}}{2} + h_3 \cos \beta_{h3}) \\ & + F_{xu6} (\frac{T_{OR}}{2} - h_4 \cos \beta_{h4}) - F_{xu5} (\frac{T_{OR}}{2} + h_3 \cos \beta_{h3}) \\ & + \sum_{i=1}^{2} M_{ZFi} + \sum_{i=3}^{4} M_{ZRi}\end{aligned} \tag{267}$$

$$\Sigma N_{\phi u} = (S_2 - S_1) \frac{T_F}{2} + (S_4 - S_3) \frac{T_{SR}}{2}$$

$$- F_{yu1} (z_F + \delta_1 + h_1 \cos \gamma_{h1} - H_{FC})$$

$$- F_{yu2} (z_F + \delta_2 + h_2 \cos \gamma_{h2} - H_{FC})$$

$$- (F_{yu3} + F_{yu4} + F_{yu5} + F_{yu6}) (z_R + \delta_R)$$

$$+ \sum_{i=1}^{2} M_{XFi} \qquad (268\text{-H})$$

$$\Sigma N_{\theta u} = (S_1 + S_2) a - (S_3 + S_4) b$$

$$+ F_{xu1} (z_F + \delta_1 + h_1 \cos \gamma_{h1})$$

$$+ F_{xu2} (z_F + \delta_2 + h_2 \cos \gamma_{h2})$$

$$+ F_{xu3} (z_R + \delta_R - Z_{3ID} + \frac{T_{IR}}{2} \phi_R)$$

$$+ F_{xu4} (z_R + \delta_R - Z_{4ID} - \frac{T_{IR}}{2} \phi_R)$$

$$+ F_{xu5} (z_R + \delta_R - Z_{5OD} + \frac{T_{OR}}{2} \phi_R)$$

$$+ F_{xu6} (z_R + \delta_R - Z_{6OD} - \frac{T_{OR}}{2} \phi_R) \qquad (269\text{-H})$$

$$\Sigma\ N_{\phi R} = (S_3 - S_4)\ \frac{T_{SR}}{2} + 2\ F_{zu3}\ (T_{OIR} + Z_{3DE}\ \phi_R)$$

$$- 2\ F_{zu4}\ (T_{OIR} - Z_{4DE}\ \phi_R) - F_{yu3}\ (-Z_{3ID} + \frac{T_{IR}}{2}\ \phi_R)$$

$$- F_{yu4}\ (-Z_{4ID} - \frac{T_{IR}}{2}\ \phi_R)$$

$$- F_{yu5}\ (-Z_{5OD} + \frac{T_{OR}}{2}\ \phi_R)$$

$$- F_{yu6}\ (-Z_{6OD} - \frac{T_{OR}}{2}\ \phi_R)$$

$$+ \sum_{i=3}^{4} M_{XRi} \tag{270}$$

2.23.5 Radial Tire Force and Rolling Radius

$$F_{3RID} = K_{T3}\ (R_w + Z_{3ID}) \qquad (R_w + Z_{3ID}) > 0$$

$$= 0 \qquad (R_w + Z_{3ID}) \leq 0 \tag{271}$$

$$F_{4RID} = K_{T4}\ (R_w + Z_{4ID}) \qquad (R_w + Z_{4ID}) > 0$$

$$= 0 \qquad (R_w + Z_{4ID}) \leq 0 \tag{272}$$

$$F_{5ROD} = K_{T3}\ (R_w + Z_{5OD}) \qquad (R_w + Z_{5OD}) > 0$$

$$= 0 \qquad (R_w + Z_{5OD}) \leq 0 \tag{273}$$

$$F_{6ROD} = K_{T4} (R_w + Z_{6OD}) \qquad (R_w + Z_{6OD}) > 0$$

$$= 0 \qquad (R_w + Z_{6OD}) \leq 0 \qquad (274)$$

$$T_{OIR} = \frac{T_{IR} + T_{OR}}{4} \qquad (275)$$

$$T_{IOR} = \frac{T_{IR} - T_{OR}}{4} \qquad (276)$$

$$Z_{3DE} = Z - a_{31} b + a_{32} T_{OIR} + a_{33} (z_R + T_{OIR} \phi_R + \delta_R) \qquad (277)$$

$$Z_{4DE} = Z - a_{31} b - a_{32} T_{OIR} + a_{33} (z_R - T_{OIR} \phi_R + \delta_R) \qquad (278)$$

$$Z_{3ID} = Z_{3DE} + T_{IOR} (\phi + \phi_R) \qquad (279)$$

$$Z_{4ID} = Z_{4DE} - T_{IOR} (\phi + \phi_R) \qquad (280)$$

$$Z_{5OD} = Z_{3DE} - T_{IOR} (\phi + \phi_R) \qquad (281)$$

$$Z_{6OD} = Z_{4DE} + T_{IOR} (\phi + \phi_R) \qquad (282)$$

where

$$h_{3(0)} = h_{4(0)} = R_w - \frac{g}{4K_{T3}} [M_{ur} + (\frac{a}{a + b}) M_S] \qquad (283)$$

2.23.6 Tire Circumferential Force

$$F_{CiID} = -\mu'_{iID} F_{iRID} \qquad i = 3, 4 \qquad (284)$$

$$F_{CiOD} = -\mu'_{iOD} F_{iROD} \qquad i = 5, 6 \qquad (285)$$

2.23.7 Circumferential Friction Coefficient

$$\mu'_{iID} = m_{1i}\, S_{iID} \qquad \text{for } S_{iID} \leq SI_i$$

$$= m_{2i}\, S_{iID} + \mu_{0i} \qquad \text{for } S_{iID} > SI_i \tag{286}$$

$$i = 3,\ 4$$

$$\mu'_{iOD} = m_{1(i-2)}\, S_{iID} \qquad \text{for } S_{iID} \leq SI_{(i-2)}$$

$$= m_{2(i-2)}\, S_{iID} + \mu_{0(i-2)} \qquad \text{for } S_{iID} > SI_{(i-2)} \tag{287}$$

$$i = 5,\ 6$$

$$\mu_{yiID} = (B_{1R}\, F_{iRID} + B_{2R}\, C_{vi} + B_{3R}$$

$$+ B_{4R}\, F_{iRID}{}^2)\ SN_i \tag{288}$$

$$i = 3,\ 4$$

$$\mu_{yiOD} = (B_{1R}\, F_{iROD} + B_{2R}\, C_{v(i-2)} + B_{3R}$$

$$+ B_{4R}\, F_{iROD}{}^2)\ SN_{(i-2)} \tag{289}$$

$$i = 5,\ 6$$

2.23.8 Wheel Slip

$$(SLIP)_i = 1 \qquad \text{for } \xi_i > 1$$

$$= \xi_i \qquad \text{for } -1 \leq \xi_i \leq 1$$

$$= -1 \qquad \text{for } \xi_i < -1 \tag{290}$$

where

$$\xi_i = 1 + \frac{\omega_i Z_{iDE}}{u_{Gi} \cos \psi_i + v_{Gi} \sin \psi_i} \tag{291}$$

$$i = 3, 4$$

$$S_{iID} = 1 \qquad \text{for } \xi_i > 1$$

$$= \xi_i \qquad \text{for } -1 \leq \xi_i \leq 1$$

$$= -1 \qquad \text{for } \xi_i < -1 \tag{292}$$

$$\xi_i = 1 + \frac{\omega_i Z_{iID}}{u_{GiID} \cos \psi_i + v_{GiID} \sin \psi_i} \tag{293}$$

$$i = 3, 4$$

$$S_{iOD} = 1 \qquad \text{for } \xi_i > 1$$

$$= \xi_i \qquad \text{for } -1 \leq \xi_i \leq 1$$

$$= -1 \qquad \text{for } \xi_i < -1 \tag{294}$$

$$\xi_i = 1 + \frac{\omega_{(i-2)} Z_{iOD}}{u_{GiOD} \cos \psi_{(i-2)} + v_{GiOD} \sin \psi_{(i-2)}} \tag{295}$$

$$i = 5, 6$$

$$u_{G3ID} = u_{3ID} + \theta w_{3ID} \tag{296}$$

$$u_{G4ID} = u_{4ID} + \theta w_{4ID} \tag{297}$$

$$u_{G5OD} = u_{5OD} + \theta w_{5OD} \quad (298)$$

$$u_{G6OD} = u_{6OD} + \theta w_{6OD} \quad (299)$$

$$v_{G3ID} = v_{3ID} - \phi w_{3ID} \quad (300)$$

$$v_{G4ID} = v_{4ID} - \phi w_{4ID} \quad (301)$$

$$v_{G5OD} = v_{5OD} - \phi w_{5OD} \quad (302)$$

$$v_{G6OD} = v_{6OD} - \phi w_{6OD} \quad (303)$$

$$u_{3ID} = u_3 - T_{IOR}\ r \quad (304)$$

$$u_{4ID} = u_4 + T_{IOR}\ r \quad (305)$$

$$u_{5OD} = u_3 + T_{IOR}\ r \quad (306)$$

$$u_{6OD} = u_4 - T_{IOR}\ r \quad (307)$$

$$v_{3ID} = v - br - z_R p + Z_{3ID}\ (p + \dot{\phi}_R) \quad (308)$$

$$v_{4ID} = v - br - z_R p + Z_{4ID}\ (p + \dot{\phi}_R) \quad (309)$$

$$v_{5OD} = v - br - z_R p + Z_{5OD}\ (p + \dot{\phi}_R) \quad (310)$$

$$v_{6OD} = v - br - z_R p + Z_{6OD}\ (p + \dot{\phi}_R) \quad (311)$$

$$w_{3ID} = w_3 + T_{IOR}\ (p + \dot{\phi}_R) \quad (312)$$

$$w_{4ID} = w_4 - T_{IOR}\ (p + \dot{\phi}R) \quad (313)$$

$$w_{50D} = w_3 - T_{IOR}\ (p + \dot{\phi}_R) \tag{314}$$

$$w_{60D} = w_4 + T_{IOR}\ (p + \dot{\phi}_R) \tag{315}$$

2.23.9 Wheel Rotational Equations

Analog:

$$(I_{WR} + \frac{1}{4}\ I_{DR}\ \overline{AR}_R{}^2)\ \dot{\omega}_3 + (\frac{1}{4}\ I_{DR}\ \overline{AR}_R{}^2)\ \dot{\omega}_4$$

$$= 2(F_{C3}\ Z_{3DE}) + \overline{TQ}_3 \tag{316}$$

$$(I_{WR} + \frac{1}{4}\ I_{DR}\ \overline{AR}_R{}^2)\ \dot{\omega}_4 + (\frac{1}{4}\ I_{DR}\ \overline{AR}_R{}^2)\ \dot{\omega}_3$$

$$= 2(F_{C4}\ Z_{4DE}) + \overline{TQ}_4 \tag{317}$$

$$F_{C3} = -\mu_3'\ F_{R3} \tag{318}$$

$$F_{C4} = -\mu_4'\ F_{R4} \tag{319}$$

2.23.10 Tire Side Force

$$F_{SiID} = F_{iRID}\ \{|\mu_{yiID}\ g(\overline{\beta}_i)| - [|\mu_{yiID}\ g(\overline{\beta}_i)|$$

$$-\mu_{SR}\ |\sin\ (\beta_i)|\ SN_i]\ F_i\}\ \mathrm{sgn}\ g(\overline{\beta}_i) \tag{320}$$

$$i = 3,\ 4$$

$$F_{SiOD} = F_{iROD}\ \{|\mu_{yiOD}\ g\left(\overline{\beta}_{(i-2)}\right)| - [|\mu_{yiOD}\ g\left(\overline{\beta}_{(i-2)}\right)|$$

$$-\mu_{SR}\ |\sin\ \left(\beta_{(i-2)}\right)|\ SN_{(i-2)}]\ F_{i-2}\}\ \mathrm{sgn}\ g\left(\overline{\beta}_{(i-2)}\right)$$

$$i = 5,\ 6 \tag{321}$$

2.23.11 Velocities of Tire Contact Points

$$u_3 = u - T_{OIR}\, r + z_R\, q \tag{322}$$

$$u_4 = u + T_{OIR}\, r + z_R\, q \tag{323}$$

$$u_5 = u - T_{OIR}\, r + z_R\, q \tag{324}$$

$$u_6 = u + T_{OIR}\, r + z_R\, q \qquad (325\_$$

$$v_3 = v - br - [z_R - Z_{3DE}]\, p + Z_{3DE}\, \dot{\phi}_R \tag{326}$$

$$v_4 = v - br - [z_R - Z_{4DE}]\, p + Z_{4DE}\, \dot{\phi}_R \tag{327}$$

$$v_5 = v - br - [z_R - Z_{3DE}]\, p + Z_{3DE}\, \dot{\phi}_R \tag{328}$$

$$v_6 = v - br - [z_R - Z_{4DE}]\, p + Z_{4DE}\, \dot{\phi}_R \tag{329}$$

$$w_3 = w + bq + \dot{\delta}_R + (p + \dot{\phi}_R)\, T_{OIR} \tag{330}$$

$$w_4 = w + bq + \dot{\delta}_R - (p + \dot{\phi}_R)\, T_{OIR} \tag{331}$$

$$w_5 = w + bq + \dot{\delta}_R + (p + \dot{\phi}_R)\, T_{OIR} \tag{332}$$

$$w_6 = w + bq + \dot{\delta}_R - (p + \dot{\phi}_R)\, T_{OIR} \tag{333}$$

Wheel velocities in the ground plane:

$$u_{Gi} = u_i + \theta w_i \tag{334}$$

$$v_{Gi} = v_i - \phi w_i \qquad i = 3, 4, 5, 6 \tag{335}$$

2.24 Resultant Moments of Solid Front Axle and Dual Tires on Solid Rear Axle

$$\Sigma N_{\phi u} = (S_2 - S_1) \frac{T_{SF}}{2} + (S_4 - S_3) \frac{T_{SR}}{2}$$

$$- (F_{yu1} + F_{yu2}) (z_F + \delta_F)$$

$$- (F_{yu3} + F_{yu4} + F_{yu5} + F_{yu6}) (z_R + \delta_R) \qquad (336\text{-I})$$

$$\Sigma N_{\theta u} = (S_1 + S_2) a - (S_3 + S_4) b$$

$$+ F_{xu1} (z_F + \delta_F + \frac{T_F}{2} \phi_F + h_1 \cos \gamma_{h1})$$

$$+ F_{xu2} (z_F + \delta_F - \frac{T_F}{2} \phi_F + h_2 \cos \gamma_{h2})$$

$$+ F_{xu3} (z_R + \delta_R + \frac{T_{IR}}{2} \phi_R - Z_{3ID})$$

$$+ F_{xu4} (z_R + \delta_R - \frac{T_{IR}}{2} \phi_R - Z_{4ID})$$

$$+ F_{xu5} (z_R + \delta_R + \frac{T_{OR}}{2} \phi_R - z_{5ID})$$

$$+ F_{xu6} (z_R + \delta_R - \frac{T_{OR}}{2} \phi_R - Z_{6ID}) \qquad (337\text{-I})$$

3. NOTATION AND LIST OF SYMBOLS

3.1 Notation

The time derivative of a variable is indicated by a dot over the symbol for the variable, e.g.,

$$\dot{\alpha} = d\alpha/dt, \qquad \ddot{\alpha} = d^2\alpha/dt^2 .$$

Special symbols for mathematical operations are

$$|\alpha| = \text{absolute value of } \alpha$$

$$\text{sgn } \alpha = \text{algebraic sign of } \alpha \ .$$

The following subscript notation is used:

i = wheel identification number; 1 = right front, 2 = left front, 3 = right rear, 4 = left rear, 5 = right rear outside, 6 = left rear outside

j = identification of vehicle end; j = F, R for the front and the rear, respectively.

s = sprung mass

u = unsprung mass

F = front, or front axle

R = rear, or rear axle

The technical dimension system is employed with the fundamental units of lb (force), in. (length), and s (time).

3.2 List of Symbols

3.2.1 Variables

A_x, A_y = Longitudinal and lateral accelerations, respectively, of the sprung mass (g)

a_{ij} = Elements of the 3 x 3 transformation matrix relating the orientation of the vehicle fixed axis system to the inertial frame of reference.

C_L, C_M, C_N = Aerodynamic moment coefficients, given as tabular functions of τ for $\alpha = 0$

C_{vi} = Resultant velocity of the contact point of wheel i in the ground plane, (in./s)

C_X, C_Y, C_Z = Aerodynamic force coefficients, given as tabular functions of τ for $\alpha = 0$

d_{CG} = Horizontal distance between aerodynamic center and sprung mass center of gravity (in.)

F_{1Fi}, F_{1Ri} = Coulomb damping force in front and rear suspensions, respectively (lb)

F_{2Fi}, F_{2Ri} = Suspension force produced by deflection of springs and bump stops in front and rear suspensions, respectively (lb)

F_{3Fi}, F_{3Ri} = Viscous damping force in front and rear suspensions, respectively (lb)

F_{4Fi}, F_{4Ri} = Suspension force produced by auxiliary roll stiffness in front and rear suspensions, respectively (lb)

F_{APFi}, F_{APRi} = Antipitch force in front and rear suspensions, respectively (lb)

F_{ARFi}, F_{ARRi} = Antiroll force in front and rear suspensions, respectively (lb)

F_{BSi} = Suspension force component which is the difference between analog value and actual spring characteristic at wheel i (lb)

F_{Ci} = Tire circumferential force at wheel i (lb)

F_{CiID}, F_{CiOD} = Dual tire circumferential force at rear inside and outside wheels, respectively (lb)

F_{Cxui}, F_{Cyui}, F_{Czui} = Components of the circumferential force for tire i resolved along the vehicle axes (lb)

FF, FR = Front and rear brake torque curves that are input as functions of brake line pressure (lb-in.)

$F_i[(SLIP)_i]$ = Nondimensional tire side-force shaping function versus longitudinal slip at wheel i

F_{iRID}, F_{iROD} = Dual tire radial force at rear inside and outside wheel, respectively (lb)

F_{Ri} = Tire normal force to ground at wheel i (lb)

F'_{Ri} = Tire radial force at wheel i (lb)

F_{Rxui}, F_{Ryui}, F_{Rzui} = Components of the radial force for tire i resolved along the vehicle axes (lb)

F_{SABSi} = Suspension force component which is the difference between analog value and actual shock absorber characteristic at wheel i (lb)

F_{Si} = Tire side force at wheel i (lb)

F_{SiID}, F_{SiOD} = Dual tire side force at rear inside and outside wheels, respectively (lb)

F_{SWF}, F_{SWR} = Front and rear static force component of the sprung mass (lb)

F_{Sxui}, F_{Syui}, F_{Szui} = Components of the side force for tire i resolved along the vehicle axes (lb)

F_{xui}, F_{yui}, F_{zui} = Tire force components at wheel i along the sprung mass x, y, and z axes, respectively (lb)

ΣF_{xs}, ΣF_{ys}, ΣF_{zs} = Components of the resultant of aerodynamic forces that act directly on the sprung mass, along the sprung mass x, y, and z axes, respectively (lb)

ΣF_{xu}, ΣF_{yu}, ΣF_{zu} = Components of the resultant of forces that act on the unsprung masses, along the sprung mass x, y, and z axes, respectively (lb)

$g(\overline{\beta}_i)$ = Nondimensional tire side force shaping function for combined slip angle and camber angle at wheel i

h_i = Rolling radius of wheel i (in.)

I'_x, I'_y, I'_z = Moment of inertia of unsprung mass (lb-in.-s^2)

I'_{xz} = Product of inertia of unsprung mass ($lb\text{-}in.\text{-}s^2$)

m_{1i}, m_{2i} = Slope of straight-line segments approximating circumferential friction coefficient at wheel i

M_{SSi} = Torque applied to front wheel i by the steering system connecting rod (lb-in.)

M_{Ti} = Moment acting at front wheel i about the kingpin axis due to tire-road contact forces (lb-in.)

M_{XFi}, M_{XRi} = Tire overturning moment at wheel i, front and rear wheels, respectively (lb-in.)

M_{XiRID}, M_{XiROD} = Dual tire overturning moment at rear inside and outside wheel, respectively (lb-in.)

M_{ZFi}, M_{ZRi} = Tire aligning moment at wheel i, front and rear wheels, respectively (lb-in.)

M_{ZiRID}, M_{ZiROD} = Dual tire aligning moment at rear inside and outside wheel, respectively (lb)-in.)

$\Sigma N_{\phi F}$, $\Sigma N_{\phi R}$ = Rolling moment acting on the front and rear axles, respectively (lb-in.)

$\Sigma N_{\phi s}$, $\Sigma N_{\theta s}$, $\Sigma N_{\psi s}$ = Components of the resultant moment of aerodynamic forcès that act directly on the sprung mass, about the sprung mass x, y, and z axes, respectively (lb-in.)

$\Sigma N_{\phi u}$, $\Sigma N_{\theta u}$, $\Sigma N_{\psi u}$ = Components of the resultant moment of forces that act on the unsprung masses, about the sprung mass x, y, and z axes, respectively (lb-in.)

$\dot{p}$, $\dot{q}$, $\dot{r}$, p, q, r = Scalar components of angular acceleration and velocity of the sprung mass, taken about the sprung mass x, y, and z axes, respectively (rad/s^2, rad/s)

$\bar{p}$, $\bar{q}$, $\bar{r}$ = Dimensionless components of angular velocity of vehicle relative to wind in vehicle-fixed axes

P_{FL} = Brake line pressure (lb/in.^{2})

q_a = Dynamic pressure (lb/in.^{2})

S_i = Total suspension force at wheel i, effective at the wheel for independent suspensions and at the spring location for the solid front/rear axle (lb)

$(SLIP)_i$ = Longitudinal slip ratio at wheel i

S_{iID}, S_{iOD} = Longitudinal slip ratio at dual rear inside and outside wheel, respectively

T_p = Pitman torque at the steering gear box (lb-in.)

$\overline{TQ}_{Bi}$ = Brake torque at wheel i (lb-in.)

$\overline{TQ}_D$ = Drive torque (lb-in.)

$\overline{TQ}_{DMAX}$ = Maximum drive torque (lb-in)

$\dot{u}$, $\dot{v}$, $\dot{w}$, u, v, w = Scaler components of linear acceleration and velocity of the sprung mass, taken along the sprung mass x, y, and z axes, respectively (in./s^2, in./s)

u_i, v_i, w_i = Velocity components of the contact point of wheel i along the vehicle-fixed axes (in./s)

u_{iID}, u_{iOD} = Forward velocity component of the contact point of dual rear inside and outside wheel, respectively, along the vehicle-fixed axes (in./s)

u_r, v_r, w_r = Components of vehicle velocity relative to wind in vehicle-fixed axes (in./s)

u_{Gi} = Forward velocity of the contact point of wheel i in the ground plane (in./s)

u_{GiID}, u_{GiOD} = Forward velocity of the contact point of dual rear inside and outside wheel, respectively, in the ground plane (in./s)

V_{CW} = Magnitude of vehicle velocity relative to wind (in./s)

v_{Gi} = Lateral velocity of the contact point of wheel i in the ground plane (in./s)

v_{GiID}, v_{GiOD} = Lateral velocity of the contact point of dual rear inside and outside wheel, respectively, in the ground plane (in./s)

v_{iID}, v_{iOD} = Lateral velocity component of the contact point of dual rear inside and outside wheel, respectively, along the vehicle-fixed axes (in./s)

w_{iID}, w_{iOD} = Downward velocity component of the contact point of dual rear inside and outside wheel, respectively, along the vehicle-fixed axes (in./s)

x, y, z = Coordinates of a point relative to the vehicle-fixed coordinate axis system (in.)

X, Y, Z = Coordinates of the center of gravity of the sprung mass relative to the space-fixed coordinate axis system (in.)

$\ddot{y}_{CR}$, $\dot{y}_{CR}$, y_{CR} = Linear acceleration, velocity, and displacement of the steering system connecting rod (in./s^2, in./s, in.)

Z_i = Coordinate of individual wheel center above the road surface (in.)

Z_{iID}, Z_{iOD} = Inertial position of the rear dual inside and outside wheel center, respectively (in.)

Z_{MXi} = Wheel contact/lift-off indicator

Z_{si} = Input function to wheel center i which represents elevation change in reference surface (initially equal to zero) (in.)

Z_{3DE}, Z_{4DE} = Inertial position of a single equivalent wheel center replacing the right and left pair of rear dual wheel centers, respectively (in.)

$\cos \alpha_{ci}$, $\cos \beta_{ci}$, $\cos \gamma_{ci}$ = Direction cosines of the line of intersection of the wheel plane i and the ground plane (Note: $\cos \gamma_{ci}$ = 0 since the ground plane is assumed horizontal)

$\cos \alpha_{hi}$, $\cos \beta_{hi}$, $\cos \gamma_{hi}$ = Direction cosines of the tire radial force relative to the vehicle axis system

$\cos \alpha_{Ri}$, $\cos \beta_{Ri}$, $\cos \gamma_{Ri}$ = Direction cosines of the tire radial force relative to the inertial reference

$\cos \alpha_{ywi}$, $\cos \beta_{ywi}$, $\cos \gamma_{ywi}$ = Direction cosines of a line perpendicular to tire i in the inertial reference

α = Aerodynamic angle of attack (rad)

β = Vehicle body angle of sideslip (rad)

β_i = Slip angle at wheel i (rad)

β_i' = "Equivalent" slip angle produced by camber effects at wheel i (rad)

$\bar{\beta}_i$ = Nondimensional slip angle variable for wheel i

$\gamma_{i,i=1,\ 9}$ = Inertial terms used in the equations of motion

$\ddot{\delta}_i$, $\dot{\delta}_i$, δ_i = Suspension acceleration, velocity, and deflection relative to the vehicle from the position of static equilibrium, measured at the center of wheel i (in./s^2, in./s, in.)

$\ddot{\delta}_{FWi}$, $\dot{\delta}_{FWi}$, δ_{Fwi} = Angular acceleration, velocity, and displacement of front wheel i produced by the steering system (rad/s^2, rad/s, rad)

$\ddot{\delta}_F$, $\dot{\delta}_F$, δ_F = Suspension acceleration, velocity, and deflection relative to the vehicle from the position of static equilibrium at the center of the solid front axle (in./s^2, in./s, in.)

$\ddot{\delta}_R$, $\dot{\delta}_R$, δ_R = Suspension acceleration, velocity, and deflection relative to the vehicle from the position of static equilibrium at the center of the solid rear axle (in./s^2, in./s, in.)

δ_{Si} = Suspension deflection relative to the vehicle, measured at the center of wheel i from the position of static equilibrium at curb (no-load) condition (in.)

δ_{SW} = Steering wheel displacement (rad)

ΔC_X = Aerodynamic increment in axial force coefficient, given as tabular function of α

Δ_i = Distance between the wheel center and ground contact point (in.)

$\dot{\zeta}_i$, ζ_i = Suspension velocity and deflection relative to the vehicle from the position of static equilibrium, measured at the spring location i (in./s, in.)

ζ_{Si} = Suspension deflection relative to the vehicle, measured at the spring location from the position of static equilibrium at curb (no-load) condition (in.)

ζ_i' = Deflection of the center of wheel i (solid front/rear axle) relative to the vehicle from the position of static equilibrium (in.)

θ_{Si} = Caster angle of front wheel i relative to the vehicle-fixed coordinate axis system, positive for rearward inclination of the steering axis in the upward direction (rad)

θ_{XGi} = Angle between the vehicle x axis and ground plane at wheel i (rad)

μ'_{iID}, μ'_{iOD} = Circumferential friction coefficient at dual rear inside and outside wheels, respectively

μ_{yiID}, μ_{yiOD} = Lateral friction coefficient at dual rear inside and outside wheels, respectively

μ_{0i}, μ_{1i} = Circumferential friction coefficient at braking slip equal to 0 and 1, respectively

μ_{PF}, μ_{PR} = Peak braking friction coefficient, front and rear wheels, respectively

μ_{yi}, μ'_{i} = Lateral and circumferential friction coefficients, respectively, at wheel i

τ = Aerodynamic angle of sideslip (rad)

ϕ, θ, ψ = Euler angular coordinates (roll, pitch, and yaw angles) of the sprung mass relative to the space-fixed coordinate axis system (rad)

ϕ_i = Camber angle of wheel i relative to the vehicle-fixed coordinate axis system, positive when clockwise as viewed from the rear (rad)

ϕ_{CGi} = Camber angle of wheel i relative to the ground plane (rad)

$\ddot{\phi}_F$, $\dot{\phi}_F$, ϕ_F = Angular acceleration, velocity, and displacement of the front axle relative to the vehicle about a line parallel to the x axis through the front axle center of gravity, positive when counterclockwise as viewed from the front (rad/s^2, rad/s, rad)

$\ddot{\phi}_R, \dot{\phi}_R, \phi_R$ = Angular acceleration, velocity, and displacement of the rear axle relative to the vehicle about a line parallel to the x axis through the rear axle center of gravity, positive when clockwise as viewed from the rear (rad/s^2, rad/s, rad)

ϕ_{SAi} = Kingpin inclination angle at front wheel i (rad)

ψ_i = Steer angle of wheel i relative to the vehicle-fixed coordinate axis system, positive for clockwise steer as viewed from above vehicle (rad)

ψ_i' = Steer angle of wheel i in the ground plane (rad)

$\dot{\omega}_i, \omega_i$ = Rotational acceleration and velocity of wheel i (rad/s^2, rad/s)

3.2.2 Parameters

a, b = Distance in the x direction between the center of gravity of the sprung mass and the centerline of the front and rear wheels, respectively (in.)

a_{Li} = Length of steering linkage arm at front wheel i (in.)

a_p = Length of Pitman arm (in.)

$A_{0F}, A_{1F}, A_{2F}, A_{0R}, A_{1R}, A_{2R}$ = Coefficients of 2nd degree curves fitted to small-angle cornering stiffness, front and rear wheels, respectively

$A_{3F}, A_{4F}, A_{3R}, A_{4R}$ = Coefficients of 2nd degree curves fitted to small-angle camber stiffness, front and rear wheels, respectively

$A_{F1}, A_{F2}, A_{F3}, A_{R1}, A_{R2}, A_{R3}$ = Coefficients of functions fitted to tire aligning torque, front and rear wheels, respectively

$\overline{AR}_F, \overline{AR}_R$ = Drive axle ratio for the front and the rear, respectively, (i.e., propeller shaft speed to wheel speed)

$A\Omega_{TF}$, $A\Omega_{TR}$ = Proportionality factor defining limits of small-angle cornering and camber stiffness variation with tire loading, front and rear wheels, respectively

B_{1F}, B_{2F}, B_{3F}, B_{4F}, B_{1R}, B_{2R}, B_{3R}, B_{4R} = Coefficients of curves fitted to lateral friction coefficient, front and rear wheels, respectively

C_{iF}, C_{iR} = Coefficients of 5th degree polynomials (i = 0 to 5) fitted to wheel camber angle versus suspension deflection, front and rear wheels, respectively

C_{CR} = Viscous damping in steering gear, effective at the steering system connecting rod (lb-s/in.)

C_{FCR} = Coulomb friction in steering gear, effective at the steering system connecting rod (lb)

C'_{Fi}, C'_{Ri} = Coulomb damping for a single wheel, effective at the wheel for independent suspension and at the spring location for the solid front/rear axle, front and rear wheels, respectively

C_{y_p}, C_{y_r}, C_{z_α}, C_{z_q}, C_{ℓ_p}, C_{ℓ_r}, C_{m_α}, C_{m_q}, C_{n_p}, C_{n_r} = Aerodynamic stability derivatives

D_{iF}, D_{iR} = Coefficients of 5th degree polynomials (i = 0 to 5) fitted to wheel toe angle versus suspension deflection, front and rear wheels, respectively

E_{iF} = Coefficients of 5th degree polynomials (i = 0 to 5) fitted to front wheel caster angle versus suspension deflection

g = Acceleration due to gravity = 386.4 in./s^2

h_{FC}, h_{RC} = Distance between the ground and the static roll center of the independent front and rear suspension, respectively (in.)

H_i = Viscous damping derivative at front wheel i (lb-in.-s/rad)

I_{DF}, I_{DR} = Drive-line moment of inertia for front and rear wheel drives, respectively (lb-in.-s^2)

I_F, I_R = Moment of inertia of solid front and rear axles, respectively, about a line through its center of gravity and parallel to the x axis (lb-in.-s^2)

I_{FW} = Moment of inertia of individual front wheel about the kingpin axis (lb-in.-s^2)

I_{WF}, I_{WR} = Moment of inertia of individual wheel about its spin axis, front and rear wheels, respectively (lb-in.-s^2)

I_x, I_y, I_z = Moment of inertia of sprung mass about the x, y, and z axes, respectively (lb-in.-s^2)

I_{xz} = Product of inertia of sprung mass with respect to the x and z axes (lb-in.-s^2)

K_{CF}, K_{CR} = Lateral force compliance camber coefficient, front and rear wheels, respectively (rad/lb)

K_{Fi}, K_{Ri} = Suspension load-deflection rate for a single wheel in the quasi-linear range about the position of static equilibrium, effective at the spring location for the solid front/rear axle, and at the front/rear wheel for independent rear suspension (lb/in.)

K_{FS}, K_{RS} = Roll steer coefficient of the solid front and rear axles, respectively, positive for roll understeer (rad/rad)

K_{LR} = Rear lateral force compliance steer (rad/lb)

K_{OTF}, K_{OTR} = Front and rear overturning moment compliance camber (independent suspension) (rad/lb-in.)

K_{SC} = Flexibility in steering column and steering gear box (lb-in./rad)

K_{Si} = Suspension viscous damping rate for a single wheel in the quasi-linear range about the position of static equilibrium, effective at the spring location for the solid axle and at the wheel for independent suspension (lb-s/in.)

K_{SLi} = Flexibility in steering linkage at front wheel i (lb-in./rad)

K_{SR} = Aligning torque compliance steer coefficient at the rear wheels (rad/(lb-in.))

K_{Ti} = Tire load-deflection rate in the quasi-linear range for a single tire at wheel i (lb/in.)

K_{TQ} = Gain in drive torque (lb-s)

ℓ = Wheelbase length of vehicle (in.)

ℓ_v = Characteristic vehicle length upon which aerodynamic moment coefficients are referenced (in.)

M_{CR} = Effective mass of the steering system connecting rod (lb-s^2/in.)

M_S = Total sprung mass (lb-s^2/in.)

M_{uF}, M_{uR} = Total front and rear unsprung mass, respectively (lb-s^2/in.)

ΣM = Total vehicle mass (lb-s^2/in.)

N_G = Gear ratio of the steering gear box

O_{F0}, O_{F1}, O_{F2}, O_{F3}, O_{R0}, O_{R1}, O_{R2}, O_{R3} = Coefficients of functions fitted to tire overturning moment, front and rear wheels, respectively

P_{BF1}, P_{BF2}, P_{BR1}, P_{BR2} = Coefficients of curves fitted to peak braking friction coefficient, front and rear wheels, respectively

$P_{F0}, P_{F1}, P_{F2}, P_{R0}, P_{R1}, P_{R2}$ = Coefficients of curves fitted to anti-pitch coefficients, front and rear wheels, respectively

$\overline{PT}$ = Front wheel caster offset (in.)

R_F, R_R = Auxiliary roll stiffness at front and rear suspensions, respectively (lb-in./rad)

$R_{F0}, R_{F1}, R_{F2}, R_{R0}, R_{R1}, R_{R2}$ = Coefficients of curves fitted to anti-roll coefficients, front and rear wheels, respectively

R_w = Undeflected wheel radius (in.)

S_f = Projected frontal area of vehicle (in.^{2})

S_{Ii} = Longitudinal slip at wheel i at which peak braking friction occurs

$(SN)_{SO}$ = Skid number of simulated surface

$(SN)_T$ = Skid number of surface on which tire data were obtained

SN_i = Skid number ratio of simulated surface to tire data surface

S_{1F}, S_{1R} = Front and rear tire linear coefficient of sliding friction, respectively (1/lb)

T_F, T_R = Wheel tread width at the front and rear, respectively (in.)

T_{IR}, T_{OR} = Distance between the centers of inside and outside tires, respectively, in the y direction for solid rear axle with dual tires (in.)

T_{SF}, T_{SR} = Distance in the y direction between the spring centers for solid front and rear axles, respectively (in.)

V_c = Desired constant vehicle velocity (in./s)

v_{yw} = Velocity of cross wind in space-fixed axes, measured at sprung mass center of gravity (in./s)

y_{SAi} = Distance between the kingpin axis and wheel centerline, measured along the wheel spin axis at front wheel i (in.)

Z_{bias} = Bias constant to vertically shift the vehicle center-of-gravity position (in.)

z_F, z_R = Static distance in the z direction between the center of gravity of the sprung mass and center of gravities of the front and rear unsprung masses, respectively (in.)

δ_{FIN}, δ_{RIN} = Static displacement of the independent front/rear suspension from the position of static equilibrium due to loading condition (in.)

$\Delta\phi_i$ = Magnitude of camber play at front wheel i (rad)

$\Delta\phi_i$ = Static caster angle bias at front wheel i (rad)

$\Delta\psi_i$ = Static toe angle bias at front wheel i (rad)

ε_{pi} = Free play in steer of front wheel i (rad)

ε_{sp} = Free play in steering gear box (rad)

ζ_{FIN}, ζ_{RIN} = Static displacement of the front/rear suspension (solid front/rear axle) from the position of static equilibrium due to loading condition (in.)

λ_{Bi} = Brake torque multiplier at wheel i

λ_D = Drive torque distribution factor

μ_{SF}, μ_{SR} = Coefficient of sliding friction, front and rear wheels, respectively

ρ_a = Air density ($lb\text{-}s^2/in.^4$)

ϕ_{SAOi} = Right and left front wheel kingpin inclination angle at equilibrium suspension position (rad)

ω_{xw}, ω_{zw} = Angular velocity of wind in space-fixed axes (rad/s)

Appendix B

DESCRIPTION OF THE HYBRID COMPUTER SIMULATION LABORATORY

Figure B-1 is a diagram of the APL/JHU hybrid computer system. The primary units are the analog and digital computers, the hybrid control and data interface, the hybrid operator control console, and the remote batch station. Two types of analog computers manufactured by Electronic Associates, Inc. (EAI), are located in the hybrid laboratory, and the portion of the model programmed on the analog computer is divided between them. The entire steering system is contained on an EAI 231-R and the rotational wheel dynamics, circumferential friction coefficient calculation, tire deflection, and suspension dynamics are contained on an EAI 680.

The hybrid data and control interface permits control of the analog computer by the digital computer and exchange of data between the analog and digital computers. Data communication with the digital computer is provided by 24 multiplying digital-to-analog converters (MDAC's), 24 nonmultiplying DAC's, and 48 channels of

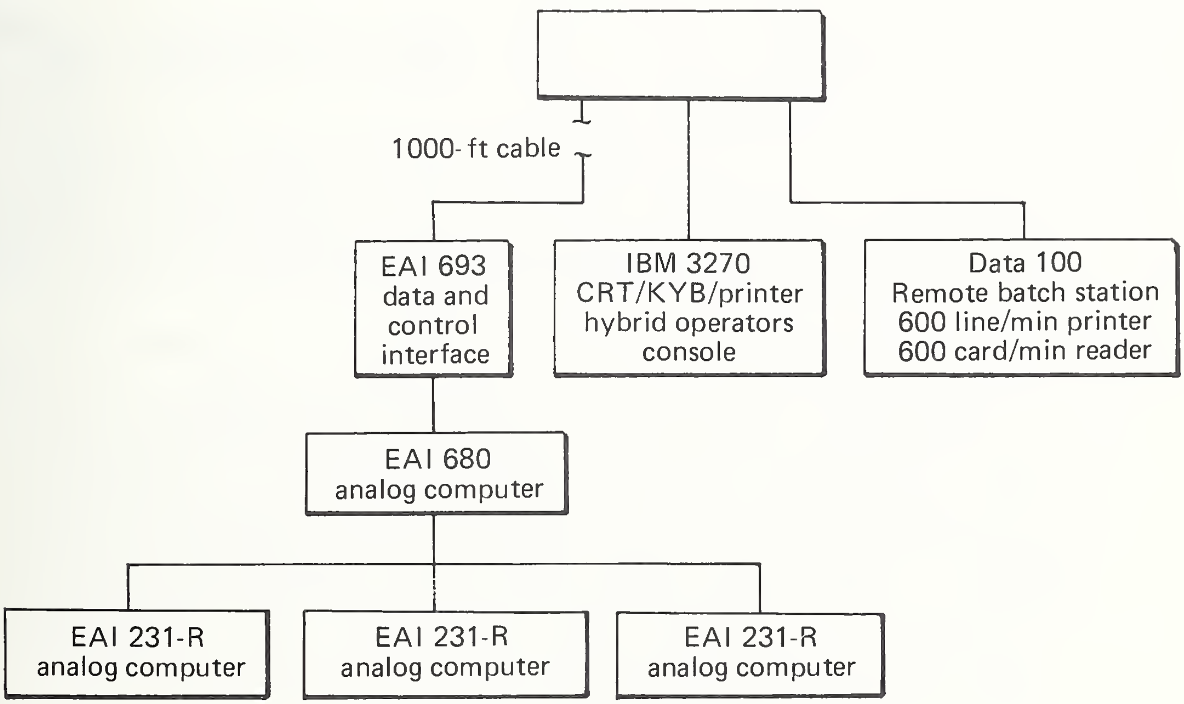


Fig. B-1 APL/JHU Hybrid Computer System Block Diagram

analog-to-digital conversion (ADC's). The system contains a control interface that allows complete control of the 680 analog computer and data interface via Fortran IV callable subroutines, by the digital computer, which is remotely located 1000 feet from the hybrid laboratory. A detailed description of the APL/JHU hybrid facility is presented in Appendix C of Ref. 10.

The digital computer is an IBM 360/91, one of the largest and fastest computers built by IBM, and is characterized by the following:

- Third generation hardware
- 4 million bytes of main core storage
- 4 billion bytes of random access storage
- Minimum instruction execution time of 60 ns
- Use of the Operating System Multiprogramming with a Variable Number of Tasks (OS/MVT)

All vehicle model calculations not assigned to the analog computers are performed digitally. Simulation coding is performed in the Fortran IV language.

Since the hybrid computing facility is remotely located from the digital computer, a remote batch terminal is required for program deck submission and the printing of digital output. The terminal in the hybrid laboratory is a Data 100 and contains a 600 card/min reader and a 600 line/min printer.

The hybrid operator control console is an IBM 3270 display system consisting of a CRT, a keyboard, and a printer. All simulation control is exercised at this station. Simulation directives, user information input via the keyboard, and simulation output appear on the CRT. The printer is used to ghost print everything that appears on the CRT so that user/computer transactions are not lost. A very powerful and flexible set of communication routines, designed for simulation use, is available to the user at the hybrid operator console. The software that services the control console is applicable to terminals other than the IBM 3270. Therefore, the simulation can be operated via a dial-up typewriter of a CRT type terminal from a remote location.

Appendix C

INTERACTIVE SUBROUTINES

1. INTRODUCTION

A set of generalized user communication subroutines has been added to the Improved Hybrid Computer Vehicle Handling Program (IHVHP) to enhance its operation by engineers. A subset of these routines directly aimed at the engineering user expedites the simulation functions of changing parameters, selecting variables for output, performing parametric runs, and general simulation control. Another subset, directed toward the simulation designer, allows tasks such as reassigning and rescaling analog-to-digital and digital-to-analog converters (ADC's and DAC's), printing the current values of all digital variables, and printing selected members of arrays. The use of these routines has allowed easy configuration of the IHVHP to perform the Vehicle Handling Test Procedures (VHTP) and to calculate the vehicle performance comparison variables.

2. SUBROUTINE USE

All simulation control occurs at the hybrid computer operator's station, which consists of a telecommunications device (teletypewriter or a CRT with keyboard). Once the simulation is active, the user controls simulation activity with input responses to the OPTION cue. Each input selects an interactive routine. Once a routine has been selected, the user is queried for information necessary to perform the task of the selected routine. When the routine is completed, the readiness of the simulation for the next routine is indicated by the reappearance of the OPTION cue. Table C-1 lists the names of the currently available interactive subroutines.

In general, the routines either alter simulation data, provide simulation control, or provide for output of simulation data. For output, the information may be directed to the hybrid operator station (T), the system line printer (L), or both (B). Also, the output can be specified as immediate (XEQ), at the end of a single-run execution (S), or at the end of each run in a multiple-run execution (M). These output selections and their codes are shown in Table C-2.

Table C-1

Interactive Subroutine List

X	Execute single simulation run	TABLE	Set up end-of-run output
XM	Execute multirun series	TRACK	Set up during-run data collection
IC	Initialize simulation	LA	List array values
F	Read or alter real variables	REMOVE	Suspend output
I	Read or alter integer variables	T+D	Output time and data
DACA	Alter DAC array	STD	Standard output
ADCA	Alter ADC array	DUMP	Output all variables
MULTI	Set up multiple runs	DACL	List DAC array
TEST	Test runs or ABEND	ADCL	List ADC array
MES	Send message to line printer	PLOT	Variable cross-plot
		TERM	Terminate program

Table C-2

Data Output Selections

Unit	Mode
T = CRT	S = Single runs only
L = System line printer	M = Multiruns only
B = Both T and L	A = Both S and M
	XEQ = Immediately

3. INTERACTIVE VARIABLES

To be effective, the routines must access, by name, the Fortran variables within a simulation. The variables of interest, termed interactive variables, need only appear in a Fortran named COMMON to be accessed. Once selected, a variable can be given any number of aliases. The alias capability is particularly important when an interactive variable is an array member. For instance, the current value of input brake line pressure, which is stored in element 121 of the PARAM array, has been given the alias PFL. Also, the PARAM array has been given the shorter alias PRM. A maximum of 400 interactive variables can be selected. However, it is important to note that the PARAM array, which has 295 elements, uses only one interactive variable allocation. Nearly all variables associated with wheel computation (side force, FSI; normal force, FRI; ground patch velocity, CVI; etc.) can be addressed as arrays and use only one interactive variable allocation. Currently, 300 interactive names have been used that permit the interrogation or alteration of more than 900 Fortran variables.

4. SUBROUTINE DESCRIPTIONS

Each subroutine is discussed, including all required inputs, and actual user examples are presented. In the examples, **** indicates user input, the remainder is computer output. Although they are not presented, the routines have extensive error handling facilities that alert a user when errors are made.

4.1 X (Execute Single Simulation Run)

Purpose: To perform a single simulation run. The simulation is automatically initialized (IC) and a run performed.

OPTION when the run is completed and all output has been printed.

Example:

```
OPTION
****  X
JUNE      20  1974
TIME  10:18:17.09
RUN   5 HAS STARTED
OUTPUT BELOW
 AXAV=   0.0   DECL TIME=   0.000 AVCUR=   0.118 BTDMAX=   0.023 BTMAX=   0.007 DELBT=   0.008
AYMAX=   0.154 PHIMAX=   1.502 RMAX=   0.088 LANE CHNG DEL=   0.0   DELFSI=   0.0   MAX STEER=  27.927
FTRQMAX=   0.0   RTRQMAX=   0.0

OPTION
```

4.2 XM (Execute Multirun Series)

Purpose: Perform a series of parametric runs. The simulation is automatically initialized (IC) prior to performing each run in the series.

Input requested: None. Control is returned to OPTION when the run series is completed and all output has been printed.

Example:

```
OPTION
****  XM
JUNE       20  1974
TIME  10:24: 7.18
RUN  10 HAS STARTED
OUTPUT BELOW
MULTI TOTAL STR4..(    1) BETAMX(    1) BETDMX(    1) CUVRAT(    1)
  1     10        28.0         0.674E-02     0.237E-01      0.111
  2     11        56.0         0.141E-01     0.465E-01      0.209
  3     12        84.0         0.254E-01     0.655E-01      0.306
  4     13        112.         0.416E-01     0.903E-01      0.394
```

4.3 IC (Initialize Simulation [do not execute])

Purpose: Resets variables back to their initial conditions. Sets potentiometers and DAC's, then returns control to OPTION.

Internal input requested: None

Example:

```
OPTION
****  IC
OPTION
```

4.4 F (Read or Alter Real Variables)

Purpose: Read current values of parameters, initial conditions, and variables which are declared REAL to Fortran. Alter current values of REAL parameters and initial conditions.

Input requested: Interactive variable only for readout, interactive variable followed by new value for altering data.

Variation: Array Readout: (a) Interactive variable followed by range of array to be output, (b) interactive variable followed by the letters AM, allowing addressing array elements by number.

Examples:

```
OPTION
****   F
ENTER
****   VHTPNO
  0.0
****   VHTPNO 5.
****   FRI 1 4
   1==>  1073.          2==>  1073.          3==>  887.7          4==>  887.7
****   PRM 285 287
 285==>  3.900        286==> 0.0           287==>  1.000
****   PRM 1 23
   1==>  12.33          2==> 0.5100          3==> 0.8200          4==>  11.30
   5==>  11.30          6==>  49.30          7==>  68.70          8==>  59.80
   9==>  61.80         10==>  47.00         11==>  3758.         12==> 0.2305E 05
  13==> 0.2333E 05     14==>  530.0         15==>  550.0         16==> 0.0
  17==> 0.4040E 05     18==>  40.00         19==>  105.0         20==>  2.000
  21==> -2.400         22==>  2.100         23==> 0.0
****   FRI AM
****   1
   1073.
****   2
   1073.
****   3
   887.7
****   4
   887.7
****   PRM AM
****   285
   3.900
****   285 4.4
****   285
   4.400
****
```

4.5 I (Read or Alter Integer Variables)

Purpose: Read current values of parameters, initial conditions, and variables that are declared INTEGER to Fortran. Alter current values of INTEGER parameters and initial conditions.

Input requested: Interactive variable only for readout, interactive variable followed by new value for altering data.

Example:

```
OPTION
*****   I
ENTER
*****   IPOT
     283
*****
```

4.6 DACA (Alter DAC Array)

Purpose: To change DAC variable assignment and/or scaling.

Inputs requested:

1. ENTER DAC NUM OR NAME

   a. Purpose: To select DAC to be altered.

   b. Input requested: The name of any interactive variable that is assigned to a DAC or a number from 1 to 48.

2. ENTER NAME

   a. Purpose: To reassign a new variable to the DAC.

   b. Input requested: Any interactive variable. Depressing the carriage return will retain the old assignment.

3. SCALE FACTOR

   a. Purpose: To enter scale factor.

   b. Input requested: Any number.

Example:

```
OPTION
**** DACA
TO RETURN TO OPTIONS  HIT CR
ENTER DAC ARRAY NUM OR NAME
****  1
DACO( 1) = IOUT..(    1) /      1.0000
ENTER NAME
****  AYMAX
SCALE FACTOR
****  1.
ENTER DAC ARRAY NUM OR NAME
****
OPTION
```

4.7 ADCA (Alter ADC Array)

Identical to DAC routine with the exception that the interactive variable is assigned to an ADC, not a DAC, and the number must be from 1 to 28.

Example:

```
OPTION
****  ADCA
TO RETURN TO OPTIONS  HIT CR
ENTER ADC ARRAY NUM OR NAME
****  20
QUAN2.(    1) = ADCO(20) *      1.0000
ENTER NAME
****  SLIPI(2)
SCALE FACTOR
****  1.
ENTER ADC ARRAY NUM OR NAME
****
```

4.8 MULTI (Set Up Multiple Runs)

Purpose: To automatically execute a series of runs. Parameters (interactive variables) may be incremented from run to run by this routine. Parameters retain their incremented value at the end of the multiple run.

Inputs requested:

1. NUMBER OF LOOPS, VARS

   a. Purpose: To specify the total number of runs to be made and the number of interactive variables to be incremented.

   b. Input requested: LOOPS, a number less than 100; VARS, a number less than 50.

2. VAR

   a. Purpose: To specify the interactive variables to be incremented. The variables are incremented at the end of each run in the multiloop. If 0 is entered, control is returned to OPTION.

   b. Input requested: Any interactive variable.

3. LOOP, VAL, INC

   a. Purpose: To specify the run number, initial value, and increment per run.

   b. Input requested: A value can be specified for each run with a 0 increment or a series can be set up by the input of an increment. The incrementing is halted at each new LOOP input or when runs equal to the total number of LOOPS have been completed.

Example:

```
OPTION
****  MULTI
NUM OF LOOPS,VARS
****  12 2
VAR
****  STR4
LOOP,VAL,INC
****  1 28. 28.
****  7 28. 28.
****
VAR
****  UIN
LOOP,VAL,INC
****  1 50. 0.
****  7 60.
****  7 60. 0.
****
OPTION
```

4.9 TEST (Test Runs or ABEND)

Purpose: To run the problem without real-time service or produce an abnormal termination (ABEND), thus giving a program dump.

Input requested:

1. ENTER: RTIME, NO RTIME, ABEND

   a. Purpose: To indicate that a command is desired.

   b. Input requested: One of three commands:

      (1) NO RTIME: This will remove the real-time calls.

      (2) RTIME: This will replace the real-time calls.

      (3) ABEND: Will produce a program dump.

Example:

```
OPTION
****  TEST
ENTER: RTIME/NO RTIME/ABEND
****  RTIME
```

4.10 MES (Send Message to Line Printer)

Purpose: To send a message to the line printer that will document analog programming changes (experimental or permanent), indicate the state of analog computer, or log simulation information.

Input requested: A message that is less than 80 characters per line long.

Example:

```
OPTION
****  MES
TO RETURN TO OPTIONS HIT CR TWICE
****  THIS OPTION IS USEFUL FOR
****  DOCUMENTING SIMULATION RUNNING
****  AND KEEPING SIMULATION NOTES
****
```

4.11 TABLE (Set up End-of-Run Output)

Purpose: To output data for a series of runs in tabular form. Designed for use in the multirun cases. This routine is called automatically whenever a multirun case is in affect, unless it is deselected.

Input requested: Up to nine interactive variables.

Example:

```
OPTION
****  TABLE
UNIT,MODE
****  T M
ENTER UP TO 9 NAMES
****  STR4 BETAMX BETDMX CUVRAT
****
```

4.12 TRACK (Set up During-Run Data Collection)

Purpose: To collect and output simulation data as a function of time.

Inputs requested:

1. TIME ON

   a. Purpose: To state the time in seconds that the routine will turn on.

   b. Input requested: Any positive number.

2. TIME OFF

   a. Purpose: To state the time in seconds that the routine will turn off.

   b. Input requested: Any positive number ≥ TIME ON.

3. TIME STEP

   a. Purpose: To state the time between samples. If this sample interval is too small, the program will automatically compensate for it.

   b. Input requested: Any positive number.

4. VARIABLES

a. Purpose: To enter the interactive variables to be tracked. Entering the word RETAIN will retain the previous variable list.

b. Inputs requested: Up to 50 variables.

Example:

```
OPTION
****  TRACK
UNIT,MODE
****  T A
ENTER TIME ON,OFF,STEP
****  .5 1.1 .1
TYPE RETAIN OR ENTER NEW ARRAY
****  PSIDT PHIDT PHI ZIMX(1) ZIMX(3)
****

 TIME   PSIDT.(   1)  PHIDT.(   1)   PHI...(   1)   ZIMX..(   1)   ZIMX..(   3)
 0.50   0.43077        0.77597E-02   -0.11728        0.29986E-01    0.10125
 0.60   0.35703        0.29683       -0.10414        0.29986E-01    0.10125
 0.70   0.28586        0.49151       -0.59047E-01    0.29986E-01    0.10125
 0.80   0.28740        0.32454       -0.16426E-01    0.29986E-01    0.10125
 0.90   0.30123        0.14344E-02   -0.12279E-03    0.29986E-01    0.10125
 1.00   0.28316       -0.14820       -0.90558E-02    0.29986E-01    0.10125
 1.10   0.29048       -0.38197       -0.30314E-01    0.29986E-01    0.10125
OPTION
```

4.13 LA (List Array Values)

Purpose: To output the values of variables that are array members.

Inputs requested: Any interactive variable that is an array, followed by the range of the array desired.

Example:

```
OPTION
****  LA
UNIT,MODE
****  T XEQ
ENTER  NAME,INDEX1,INDEX2
****  FRI 1 4
****  FSI 1 4
****  PRM 11 14
****  PARAM 11 14
****
FRI.....
   1==)  1073.        2==)  1073.         3==)  887.7         4==)  887.7
FSI.....
   1==) -10.51        2==)  10.51         3==) 0.0            4==) 0.0
PRM.....
  11==)  3832.       12==) 0.2400E 05    13==) 0.2431E 05    14==)  530.0
PARAM...
  11==)  3832.       12==) 0.2400E 05    13==) 0.2431E 05    14==)  530.0
```

4.14 REMOVE (Suspend Output)

Purpose: To cancel the execution of a selected interactive subroutine.

Input requested: Any interactive subroutine name.

Example:

```
OPTION
****   REMOVE
WHAT
****   TRACK
```

4.15 T+D (Output Time and Date)

Purpose: To display the time and date.

Example:

```
OPTION
****   T+D
UNIT,MODE
****   T XEQ
JUNE       21   1974
TIME   14:30:40.67
```

4.16 STD (Standard Output)

Purpose: Select standard end-of-run data.

Example:

```
OPTION
****   STD
UNIT,MODE
****   T XEQ
 AXAV=    0.0   DECL TIME=    0.0   AVCUR=    0.0   BTDMAX=    0.0   BTMAX=    0.0   DELBT=    0.0
AYMAX=    0.000 PHIMAX=    0.0   RMAX=    0.0   LANE CHNG DEL=    0.0   DELPSI=    0.0   MAX STEER=    0.0
FTRQMAX=    0.0   RTRQMAX=    0.0
```

4.17 DUMP (Output All Variables)

Purpose: To display the value of each interactive variable at the time the dump is selected to execute.

Example:

```
OPTION
****  DUMP
UNIT/MODE
****  I XEQ

ABBTV.= 0.0         DEL1DT= 0.0         OTM...=  63.28      S3P...= -38.00
ABI...= 0.1962E-01  DEL2DA= 0.0         P.....= 0.0         S4P...= -38.00
AFA...=  1.000      DEL2DT= 0.0         PARAM.=  8.430      TBCR3.=  2.923
AIXBR.=  3928.      DEL3DA= 0.0         PBF...= 0.0         TBCR4.=  2.923
AIXF..=  169.8      DEL3DT= 0.0         PBR...= 0.0         TBSR3.=  1.038
AIXZBR=  177.5      DLIS..= -.8000      PD1...= -.3097E-03  TBSR4.= 0.9047
AIXZF.= -352.5      DLYTB.= -.2453E-54  PFI...=  1000.      TERDAC= -.5388E 09
AIYBR.= 0.2322E 05  DSWMAX= 0.0         PHI...= 0.0         TF02..=  29.90
AIYF..=  169.8      DT....= 0.1000E-01  PHICGI= -.5630E-02  THE...= -.1215E-02
AIZBR.= 0.2944E 05  D1....= 0.0         PHIDMX= 0.0         THEDT.= 0.0
AKK1..=  1.000      D2....= -1.209      PHIDT.= 0.0         THEFNT= 0.7500
AKK2..=  1.000      D3....= 0.0         PHIFNT= -.3800      THEO..= -.1215E-02
ALFI..= -.2262E 08  D4....= 0.1146E-68  PHII..= -.6405E-02  THERR.= 0.0
ALTQ..= -46.06      ETAL..= -.1133E-05  PHIMAX= 0.0         THRD..= 0.3333
AMI1..=  25.85      ETAX..= -.2176E-03  PHIO..= 0.0         THS1..= 0.1309E-01
AMI2..= -25.85      EXTAB.= -.1278E-56  PHIRD.= 0.0         THS2..= 0.1309E-01
AMUI..= 0.9657      E1....= 0.1156E 09  PHIRDA= 0.0         TIMBMP= 0.0
AM1I..=  5.018      E2....= -.4480E 06  PHIRR.= 0.0         TIMDEC= 0.0
AM2I..= -.2466      E3....= 0.1252E 06  PO....= 0.0         TIME..= 0.0
ANGNL.= 0.1180E 09  FBS1..= 0.0         PRM...=  8.430      TIME10= 0.0
ANGNLO= 0.8392E-04  FBS2..= 0.0         PSI...= 0.0         TIME25= 0.0
ANTI1.=  1.734      FBS3..= 0.0         PSIDT.= 0.0         TIMIN5= 0.0
ANTI2.=  1.734      FBS4..= 0.0         PSIFNT= -.2700      TMAX1.= 0.9942E 28
ANTI3.= -.1425      FCI...= 0.0         PSII..= -.1558E-02  TMAX2.= 0.1991E 06
ANTI4.= -.1425      FCIMAX=  892.9      PSIMAX= 0.0         TMAX3.= -.4879E-49
AP1...= 0.1381      FI....=  1.000      PSIO..= 0.0         TMP...= 0.0
AP2...= 0.1381      FOTM..= -1.218      PSIOUT= 0.0         TQBF..= 0.0
AP3...= -.1425      FRI...=  1047.      PSIRR.= 0.0         TQBR..= 0.0
AP4...= -.1425      FRIBR.=  1047.      PSI3S.= 0.0         TQFMAX= 0.0
ARPS1.=  56.79      FSI...= -19.70      PSI4S.= 0.0         TQRMAX= 0.0
ARPS2.=  56.97      FXL1..= 0.0         PSI5..= 0.0         TRCR3.=  1.315
AR1...=  1.596      FXL2..= 0.0         PSR3..= 0.0         TRCR4.=  1.315
AR2...=  1.596      FXUI..= -1.302      PSR4..= 0.0         TRO2..=  30.90
AR3...= 0.0         FYUI..= -19.70      Q.....= 0.0         TRSR3.= 0.4669
AR4...= 0.0         G.....=  386.4      QDT...= 0.5060E-01  TRSR4.= 0.4069
AXAVE.= 0.0         GAMF..= 0.0         QO....= 0.0         TSO2..=  23.50
AXI...= 0.0         GAM1..= -31.19      QUAN1.= 0.0         TSTEP.= 0.1000E-01
AYMAX.= 0.1133E-05  GAM2..=  15.03      QUAN2.= 0.0         TWN7..= 0.3704E-01
A1....=  1.540      GAM3..=  15.03      QUAN3.= 0.0         U.....=  880.0
A12...= -1543.      GBI...= -.1949E-01  QUAN4.= 0.0         UDT...= -.8422E-01
A2....=  1545.      GETDL.= 0.0         R.....= 0.0         UGI...=  880.0
A2T...=  1900.      GI....= -.1882E-01  RDT...= -.2380E-05  UGIP..=  880.0
BAMI..= 0.2221E-02  GP1...= 0.2864E 06  RMAX..= 0.0         UI....=  880.0
BETAI.= 0.1558E-02  GP2...=  2202.      RMI...=  1011.      UIN...=  50.00
BETAMX= 0.0         GR1...=  2202.      RO....= 0.0         UO....=  880.0
BETDMX= 0.0         GR2...= 0.3811E 05  ROTM..= 0.0         UOUT..=  880.0
BETIBR= -.1962E-01  GV1...= 0.4480E 06  ROUT..= 0.0         UOI...= 0.8966
BETIP.= 0.6625E-03  GV2...= 0.1252E 06  RTAB..= -.8457E-53  U1I...= 0.6500
BMPN..= 0.0         IAX...= 0.5148E-84  RWZI..= 0.7219      U1P...= 0.0
BMPS..= 0.0         IDACK.= 0.0         RZF...=  24.50      U2P...= 0.0
BRKOFF=  1.020      IENDR.= -14.24      RZR...=  24.50      U3P...= 0.0
BRKON.= 0.5200      IERDAC= -14.24      SALTQ.= 0.0         U4P...= 0.0
BSLOPE= 0.5000E-01  IN....= -.2014E-02  SAMI..= 0.1272      V.....= 0.0
BTV...= 0.0         INA...= 0.2523E 09  SCR3..= 0.3551      VDT...= -.4844E-03
BTVDT.= -.4975E-06  IOR...= 0.8236E-83  SCR4..= 0.3095      VGI...= 0.0
```

```
CA20..= 0.6842E 07 IOUT..= 0.7892E-04 SFIN..= -100.0     VHTPNO=  6.000
CA23..=  3293.     IOUTA.= 0.2031E 38 SFOUT.=  1.000     VI....= 0.0
CIP...=  4105.     IPOT..= 0.1524E-01 SFXU..= -4.643     VO....= 0.0
CIVP..=  2046.     IPOTAD= 0.1524E-01 SFYU..= 0.0        VOUT..= 0.0
COSPSI=  1.000     IPRT..= 0.0        SINPSI= -.1558E-02 W.....= 0.0
CPSR3.=  1.000     ISW1..= 0.0        SLIPI.= 0.0        WCTH1.= -.7869
CPSR4.=  1.000     ISW7..= 0.0        SM....=  9.760     WCTH2.= -.9782
CURTBP= 0.0        ITMP..= 0.7892E-04 SN....= 0.0        WDT...=  18.51
CURVAV= 0.0        IVHTP.= 0.3089E-03 SNI...=  1.000     WI....= 0.0
CUVRAT= 0.0        JJTIME= 0.0        SNPHIU= -1.218     WO....= 0.0
CVI...=  50.00     JUMP..= 0.0        SNPSIU= 0.0        WSTH1.= 0.6163
DACO..= 0.7892E-04 MUP...= 0.8563     SNTHEU=  1166.     WSTH2.= 0.2056
DEL...= 0.0        NCAM..= 0.5432E 09 SPSR3.= 0.3551     X.....= 0.0
DELBET= 0.0        NCAS..= -.7418E-67 SPSR4.= 0.3095     XDT...=  880.0
DELFW1= 0.0        NFA...= 0.5148E-03 STR1..= 0.0        XO....= 0.0
DELFW2= 0.0        NTF...= 0.1030E-03 STR2..= 0.0        Y.....= 0.0
DELPHI= -.7662E 55 NTR...= 0.1030E-03 STR3..= 0.0        YDT...= 0.0
DELPSI= 0.0        N1....= 0.1519E-01 STR4..= 0.0        YO....= 0.0
DELSTR= 0.0        N2....= 0.6126E-02 STR5..=  223.4     Z.....= -23.84
DELTA.= 0.1118E 10 ONEOA.= -.6480E-03 STR6..=  223.4     ZDT...=  1.069
DELTHE= -.1079E-49 ONEOD.= 0.8947E-09 S1P...= -40.00     ZI....= -12.48
DEL1DA= 0.0        ONER..= -.5653E-09 S2P...= -40.00     ZIMX..= 0.7219
OPTION
```

4.18 DACL (List DAC Array)

Purpose: To list the DAC assignments and scale factors.

Example:

```
OPTION
****  DACL
UNIT/MODE
****  I XEQ
DACO( 1) = IOUT..(  1)/     1.0000
DACO( 2) = IOUT..(  2)/     1.0000
DACO( 3) = IOUT..(  3)/     1.0000
DACO( 4) = IOUT..(  4)/     1.0000
DACO( 5) = IOUT..(  5)/     1.0000
DACO( 6) = IOUT..(  6)/     1.0000
DACO( 7) = IOUT..(  7)/     1.0000
DACO( 8) = IOUT..(  8)/     1.0000
DACO( 9) = IOUT..(  9)/     1.0000
DACO(10) = IOUT..( 10)/     1.0000
DACO(11) = IOUT..( 11)/     1.0000
DACO(12) = IOUT..( 12)/     1.0000
DACO(13) = IOUT..( 13)/     1.0000
DACO(14) = IOUT..( 14)/     1.0000
DACO(15) = IOUT..( 15)/     1.0000
DACO(16) = IOUT..( 16)/     1.0000
DACO(17) = IOUT..( 17)/     1.0000
DACO(18) = IOUT..( 18)/     1.0000
DACO(19) = IOUT..( 19)/     1.0000
DACO(20) = IOUT..( 20)/     1.0000
DACO(21) = IOUT..( 32)/     1.0000
DACO(22) = IOUT..( 31)/     1.0000
DACO(23) = IOUT..( 23)/     1.0000
DACO(24) = IOUT..( 29)/     1.0000
DACO(25) = IOUT..( 25)/     1.0000
DACO(26) = IOUT..( 26)/     1.0000
DACO(27) = IOUT..( 27)/     1.0000
DACO(28) = IOUT..( 28)/     1.0000
```

```
DACO(29) = IOUT..(  24)/     1.0000
DACO(30) = IOUT..(  30)/     1.0000
DACO(31) = IOUT..(  22)/     1.0000
DACO(32) = IOUT..(  21)/     1.0000
DACO(33) = IOUT..(  33)/     1.0000
DACO(34) = IOUT..(  34)/     1.0000
DACO(35) = IOUT..(  35)/     1.0000
DACO(36) = IOUT..(  36)/     1.0000
DACO(37) = IOUT..(  37)/     1.0000
DACO(38) = ANTI1.(   1)/     10000.
DACO(39) = ANTI2.(   1)/     10000.
DACO(40) = ANTI3.(   1)/     10000.
DACO(41) = ANTI4.(   1)/     10000.
DACO(42) = ETAX..(   1)/     1.4000
DACO(43) = ETAL..(   1)/     1.4000
DACO(44) = ROUT..(   1)/     1.0000
DACO(45) = UOUT..(   1)/     1200.0
DACO(46) = VOUT..(   1)/     1200.0
DACO(47) = BTV...(   1)/     3.1400
DACO(48) = ONER..(   1)/    0.41700E-02
```

4.19 ADCL (List ADC Array)

Purpose: To list the ADC assignments and scale factors.

Example:

```
OPTION
****  ADCL
UNIT,MODE
****  T XEQ
DEL1DT(    1) = ADCO(  1)*    -100.00
DEL2DT(    1) = ADCO(  2)*    -100.00
DEL3DT(    1) = ADCO(  3)*    -100.00
DEL1DA(    1) = ADCO(  4)*     10.000
DEL2DA(    1) = ADCO(  5)*     10.000
DEL3DA(    1) = ADCO(  6)*     10.000
PHIRD.(    1) = ADCO(  7)*     1.0000
PHIRDA(    1) = ADCO(  8)*    0.25000
DELFW1(    1) = ADCO(  9)*    0.50000
DELFW2(    1) = ADCO( 10)*    0.50000
U1P...(    1) = ADCO( 11)*     2.0000
U2P...(    1) = ADCO( 12)*     2.0000
U3P...(    1) = ADCO( 13)*     2.0000
U4P...(    1) = ADCO( 14)*     2.0000
S1P...(    1) = ADCO( 15)*     1000.0
S2P...(    1) = ADCO( 16)*     1000.0
S3P...(    1) = ADCO( 17)*     1000.0
S4P...(    1) = ADCO( 18)*     1000.0
QUAN1.(    1) = ADCO( 19)*     1.0000
QUAN2.(    1) = ADCO( 20)*     1.0000
QUAN3.(    1) = ADCO( 21)*     1.0000
QUAN4.(    1) = ADCO( 22)*     1.0000
ARPS1.(    1) = ADCO( 23)*     100.00
ARPS2.(    1) = ADCO( 24)*     100.00
WSTH1.(    1) = ADCO( 25)*     1.0000
```

```
WCTH1.(,   1) = ADCO(26)*      1.0000
WSTH2.(    1) = ADCO(27)*      1.0000
WCTH2.(    1) = ADCO(28)*      1.0000
OPTION
```

4.20 PLOT (Variable Cross-Plot)

Purpose: To provide X-Y printer plot of any two variables which are included in TRACK option.

Example:

```
OPTION
*****  PLOT
UNIT,MODE
*****  L XEQ
ENTER NUMBER OF PLOTS
*****  1
ENTER DEPENDENT AND INDEPENDENT PLOT VARIABLES
*****  Y X
*****
OPTION
```

4.21 TERM (Terminate Program)

Purpose: To terminate program.

Example:

```
OPTION
*****  TERM
JUNE       21   1974
TIME  17: 5:38.72
PROGRAM TERMINATED
```

Appendix D

PERFORMANCE COMPARISON VARIABLE GRAPHS

This appendix contains the performance comparison variable (PVC) graphs for six Vehicle Handling Test Procedures (VHTP's) for four vehicles.

1. VHTP No. 1: Straight Line Braking

A_x — Average longitudinal deceleration from 35 mph to 10 mph (g)

P_B — Brake line pressure (psi)

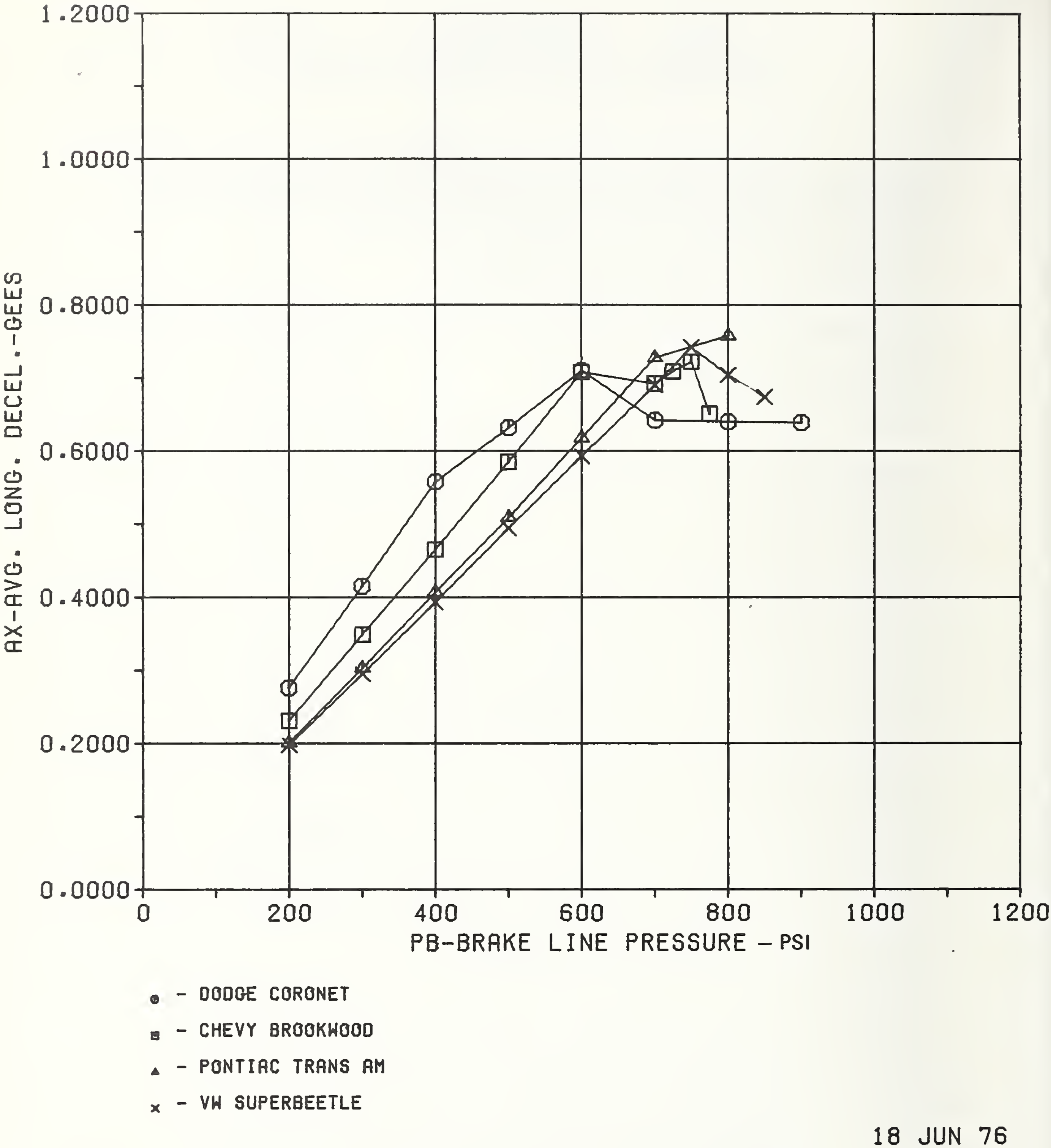


Fig. D-1 VHTP 1, Straight Line Braking: Average Longitudinal Deceleration from 35 to 10 mph versus Brake Line Pressure (Calspan, O.E. tires)

2. VHTP No. 2: Braking in a Turn

A_x — Average longitudinal deceleration from 35 mph to 10 mph (g)

P_B — Brake line pressure (psi)

BETADOT — Peak vehicle sideslip angle rate (rad/s)

$R_0(1/R)$ — Average path curvature ratio relative to initial turn

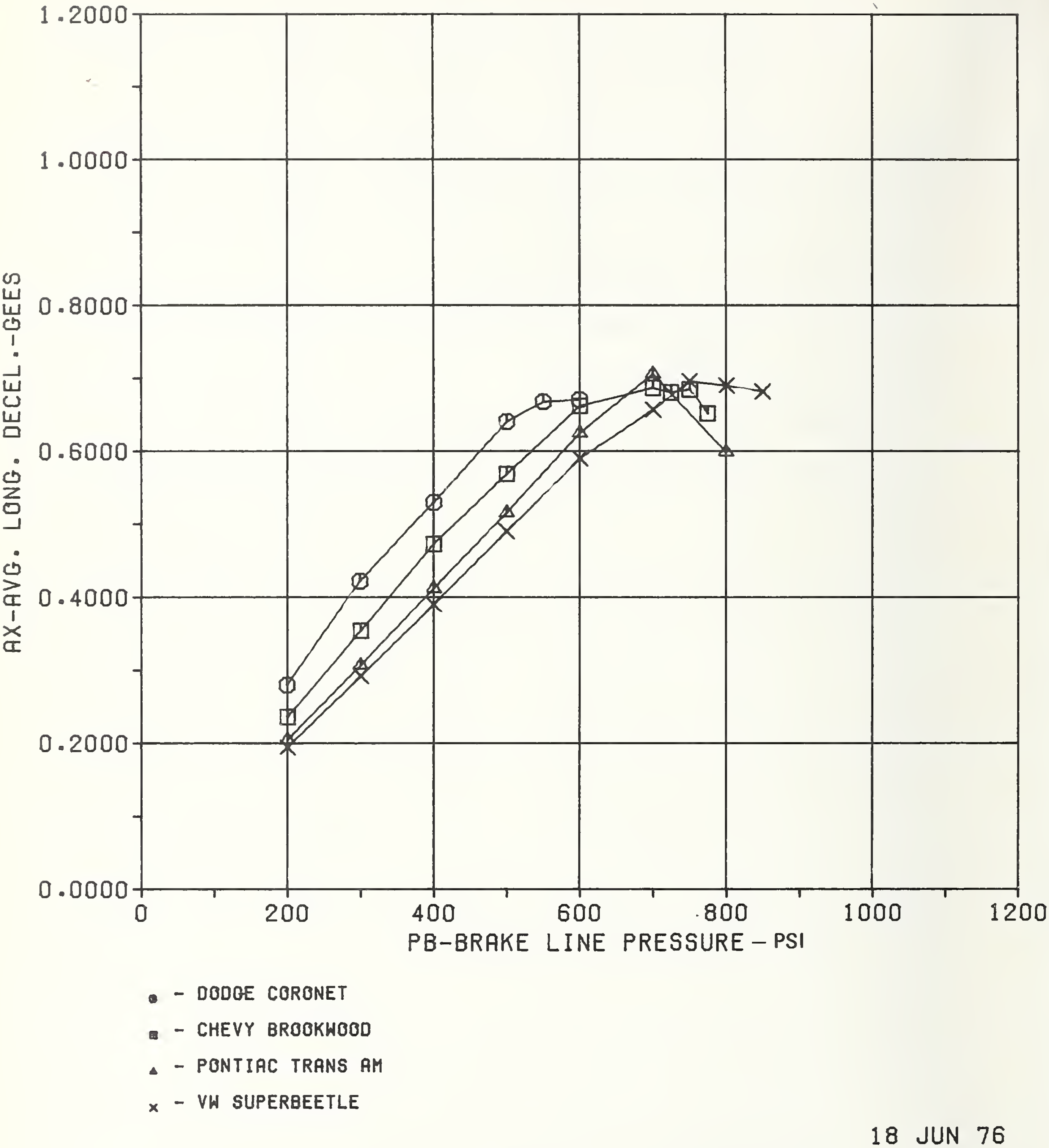


Fig. D-2 VHTP 2, Braking in a Turn: Average Longitudinal Deceleration from 35 to 10 mph versus Brake Line Pressure (Calspan, O.E. tires)

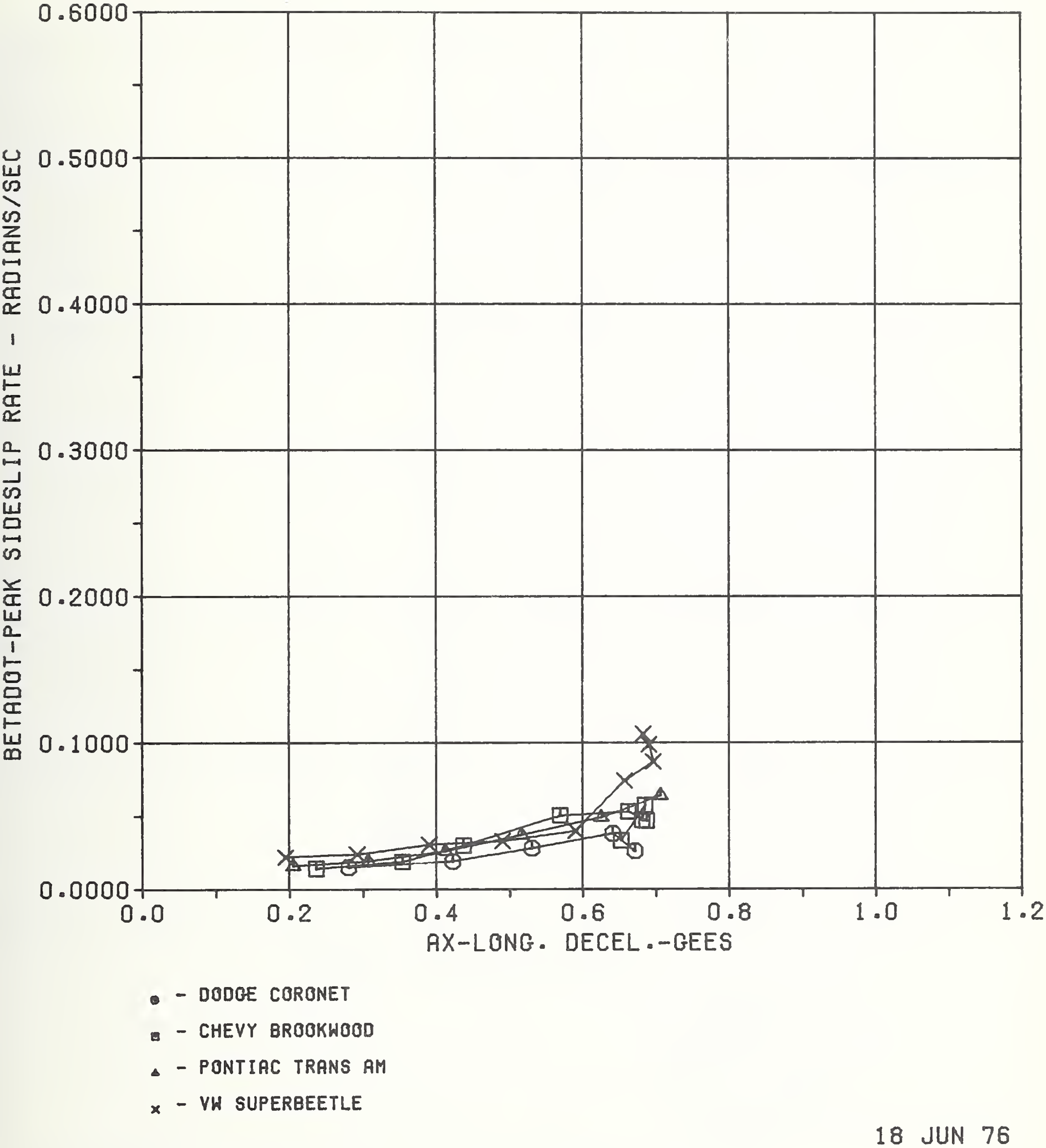
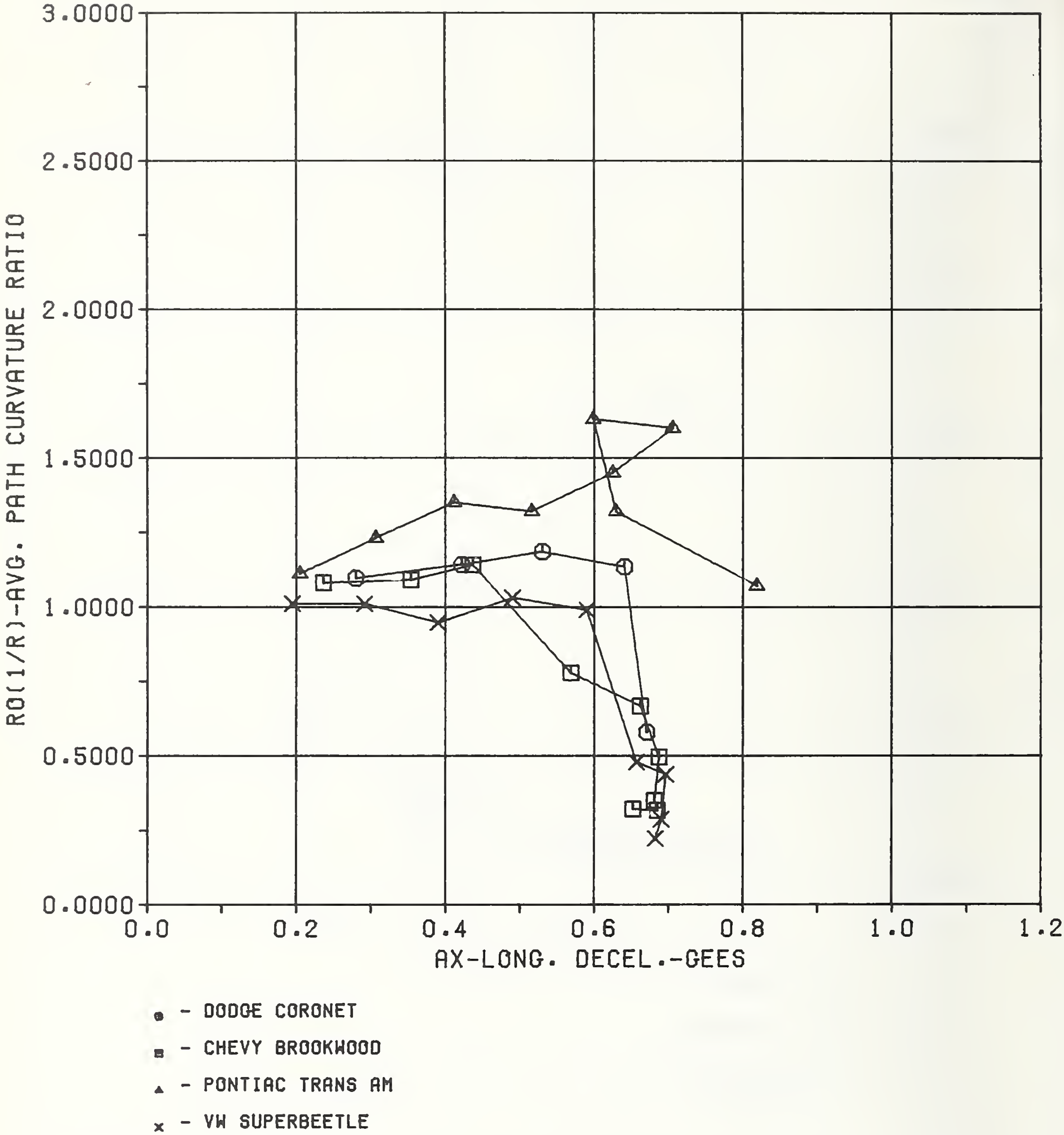


Fig. D-3 VHTP 2, Braking in a Turn: Sideslip Rate versus Average Longitudinal Deceleration from 35 to 10 mph (Calspan. O. E. tires).



18 JUN 76

Fig. D-4 VHTP 2, Braking in a Turn: Average Path Curvature Ratio versus Average Longitudinal Deceleration from 35 to 10 mph (Calspan, O. E. tires)

3. VHTP No. 3: Turning on a Rough Road

f — Roadroughness fundamental frequency, determined by spacing of the disturbance elements in each grid (Hz)

BETADOT — Peak vehicle sideslip angle rate (rad/s)

$R_0(1/R)$ — Average path curvature ratio relative to the initial turn

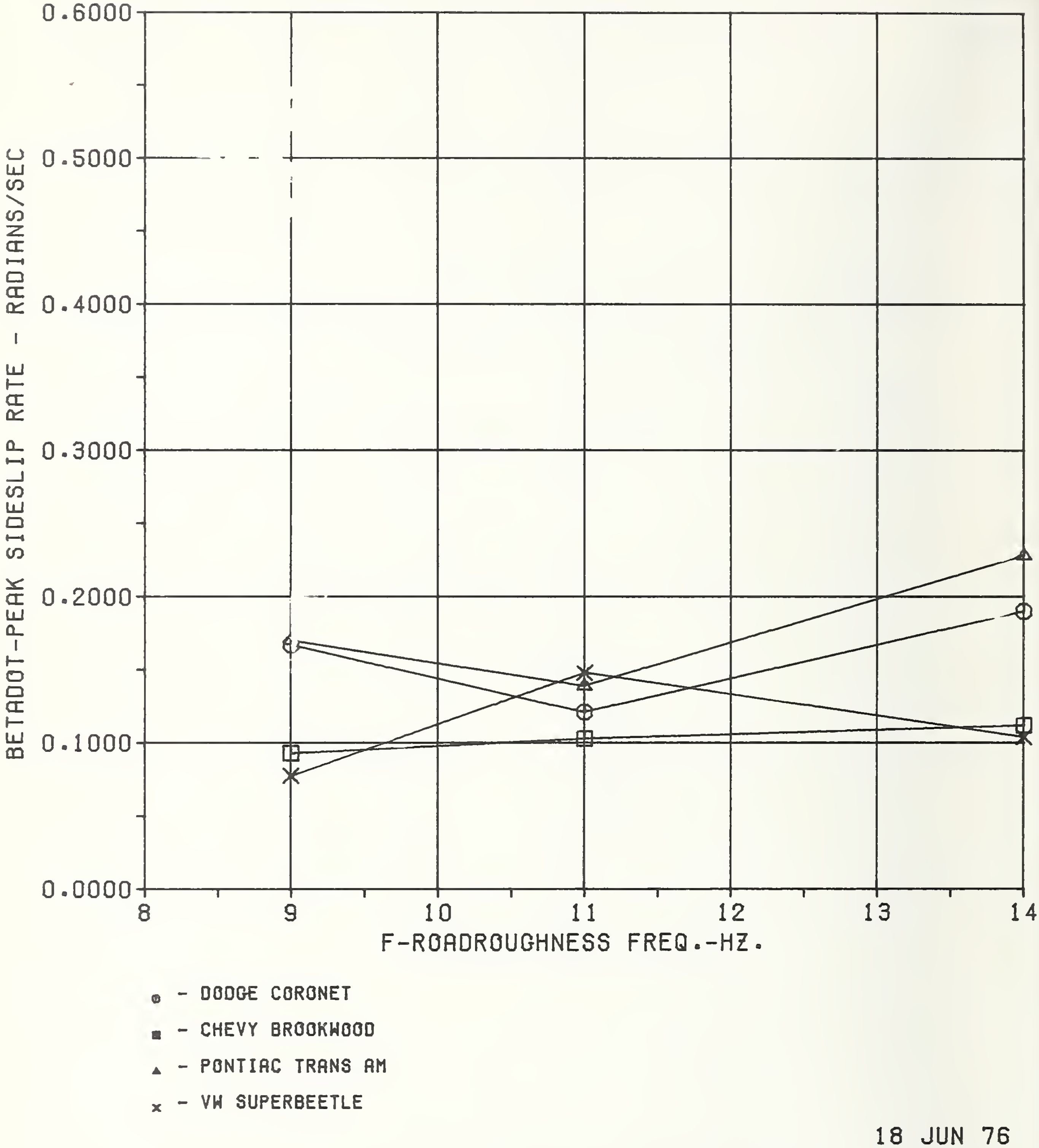


Fig. D-5 VHTP 3, Turning on a Rough Road: Sideslip Rate versus Road Roughness Frequency (Calspan, O.E. tires).

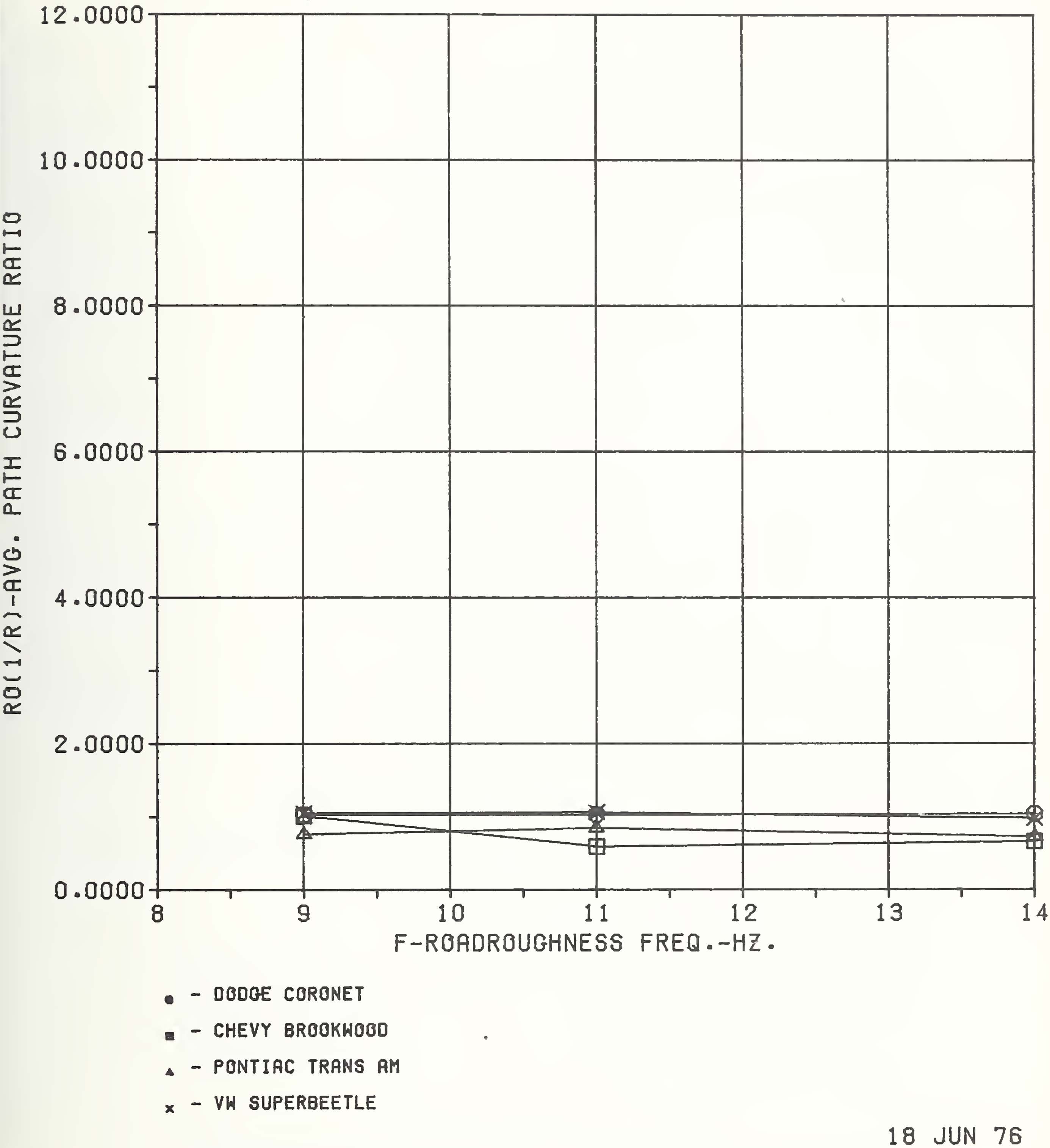


Fig. D-6 VHTP 3, Turning on a Rough Road: Average Path Curvature Ratio versus Road Roughness Frequency (Calspan, O.E. tires)

4. VHTP No. 4: Trapezoidal Steer

A_y — Peak lateral acceleration (g)

SIGMA — Normalized steer angle (deg)

R — Peak yaw rate (rad/s)

$R_s(1/R)$ — Path curvature response averaged over 2 s and ratioed to a reference path curvature deriving from a steady turn of 40 mph and 1.0g A_y

BETADOT — Peak vehicle sideslip angle rate (rad/s)

BETA — Peak vehicle sideslip angle (rad)

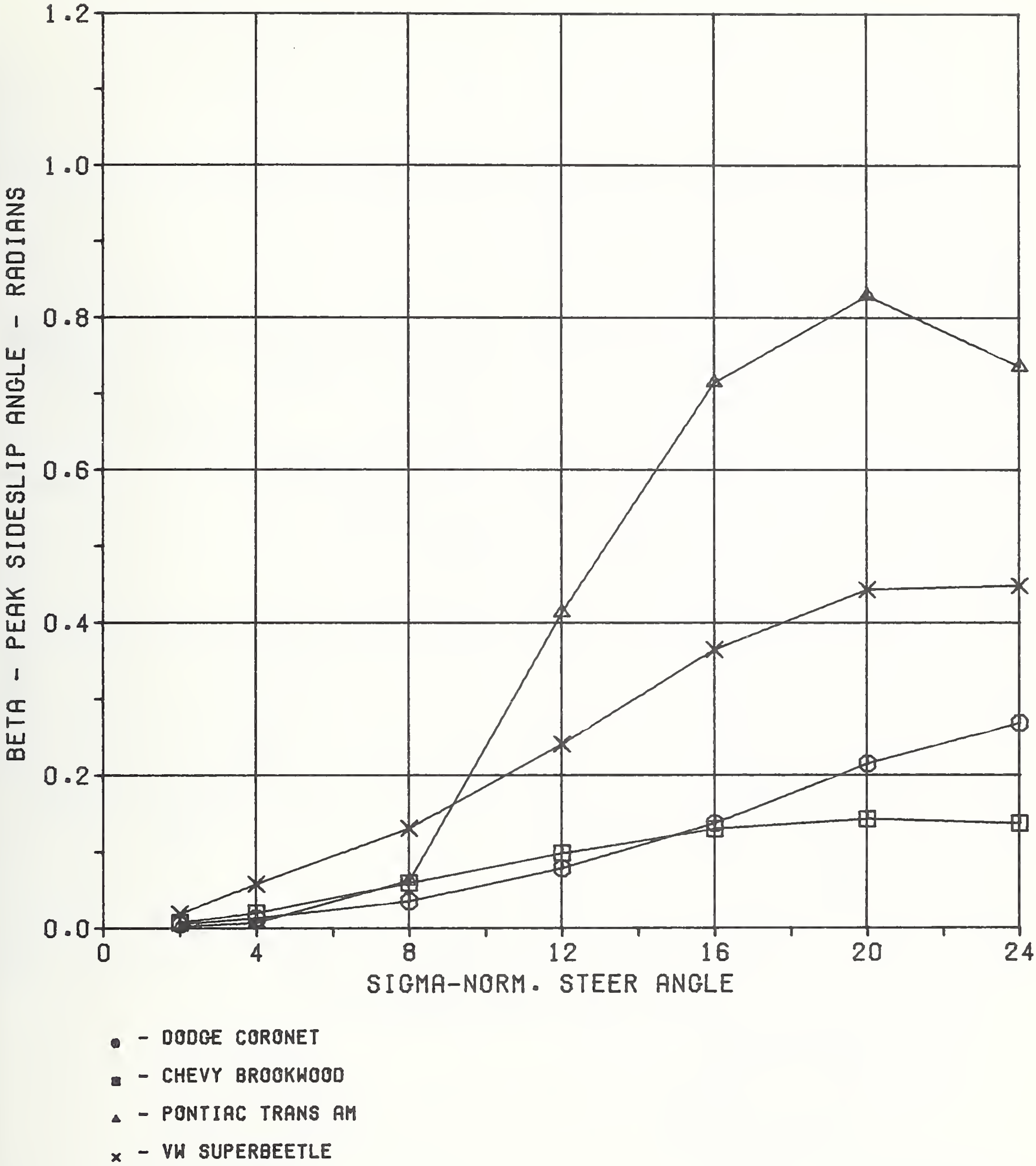


Fig. D-7 VHTP 4, Trapezoidal Steer: Sideslip Angle versus Normalized Steer Angle (Calspan, O.E. tires)

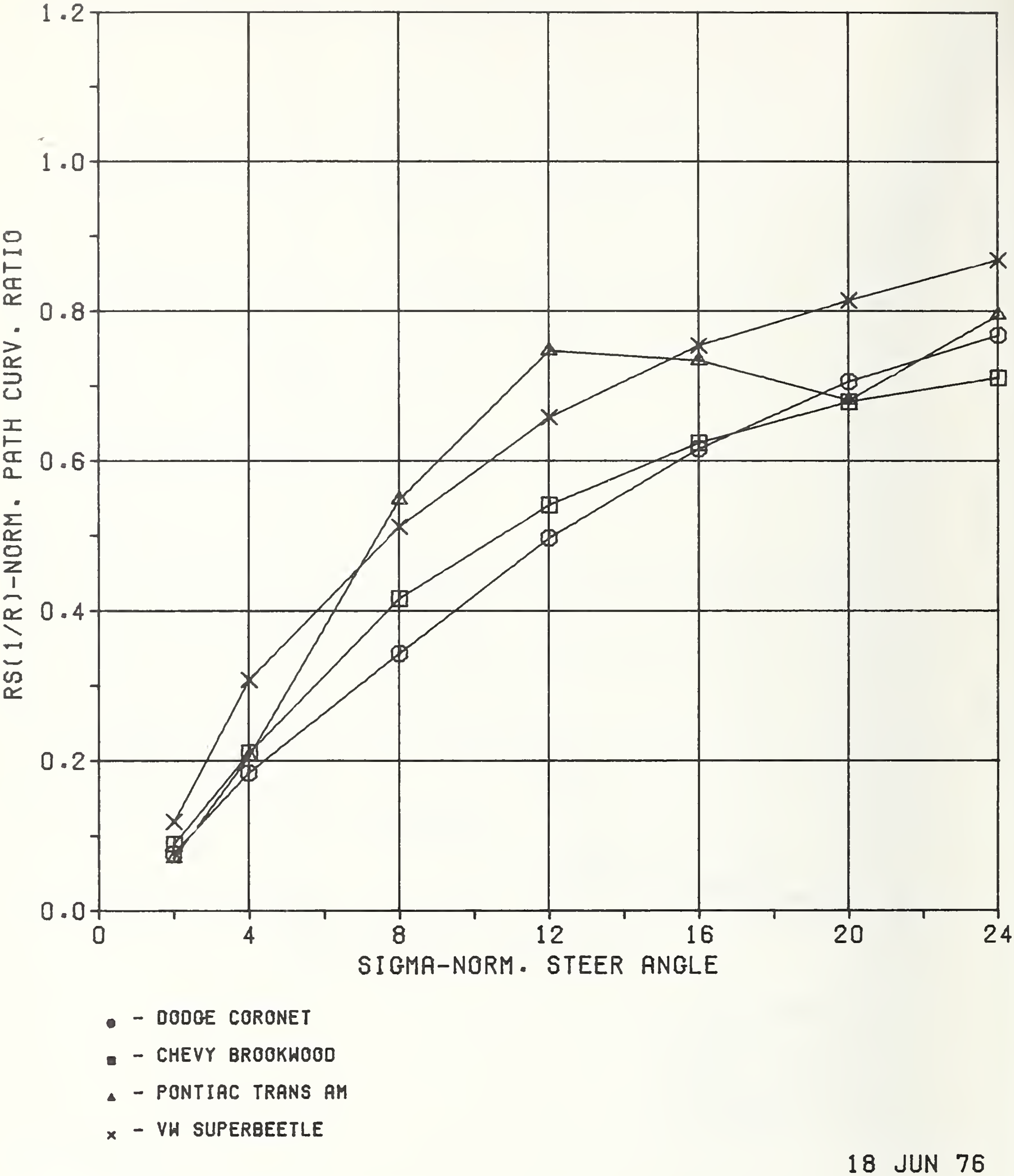


Fig. D-8 VHTP 4, Trapezoidal Steer: Normalized Curvature Ratio versus Normalized Steer Angle (Calspan, O.E. tires)

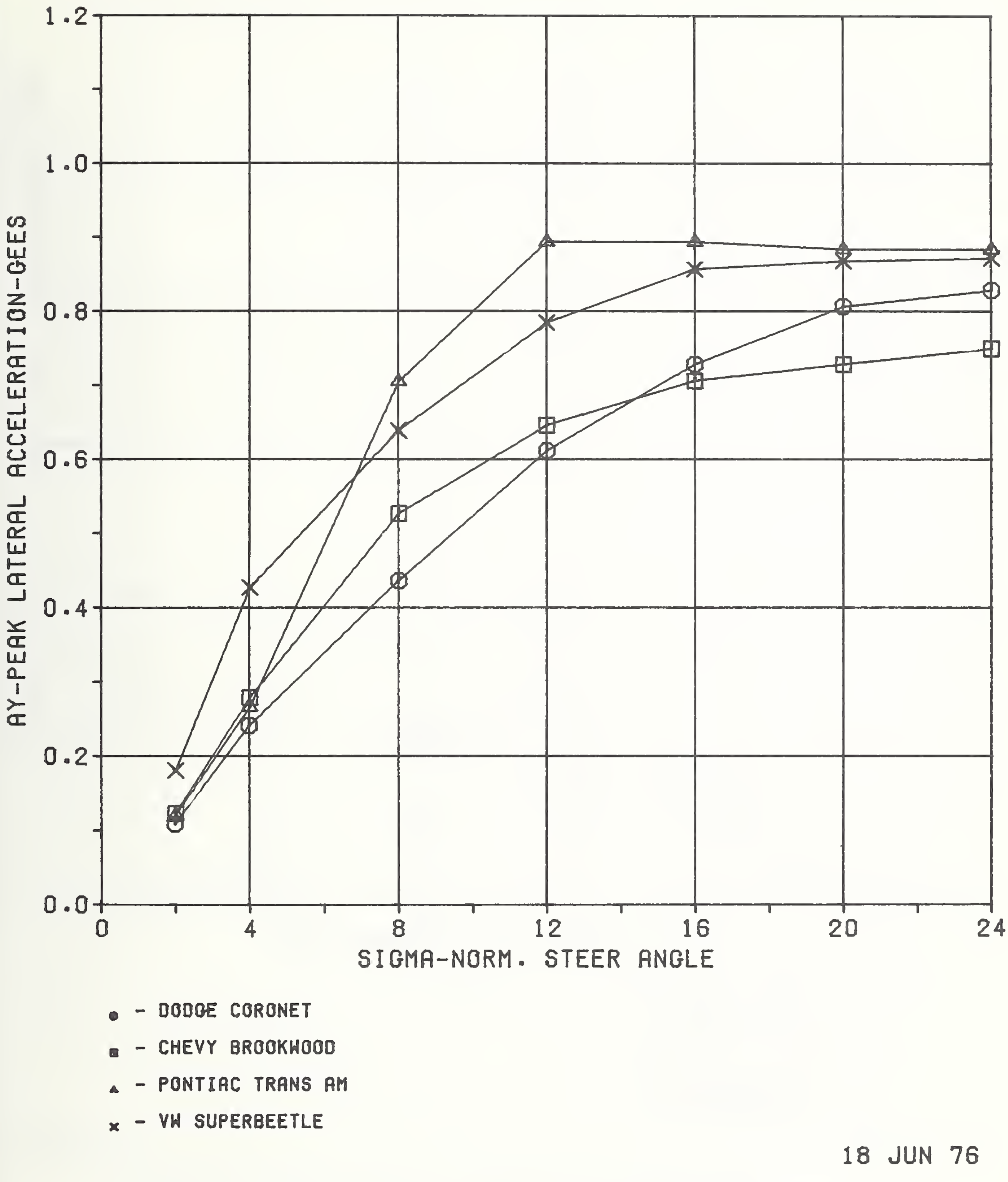


Fig. D-9 VHTP 4, Trapezoidal Steer: Lateral Acceleration versus Normalized Steer Angle (Calspan, O.E. tires)

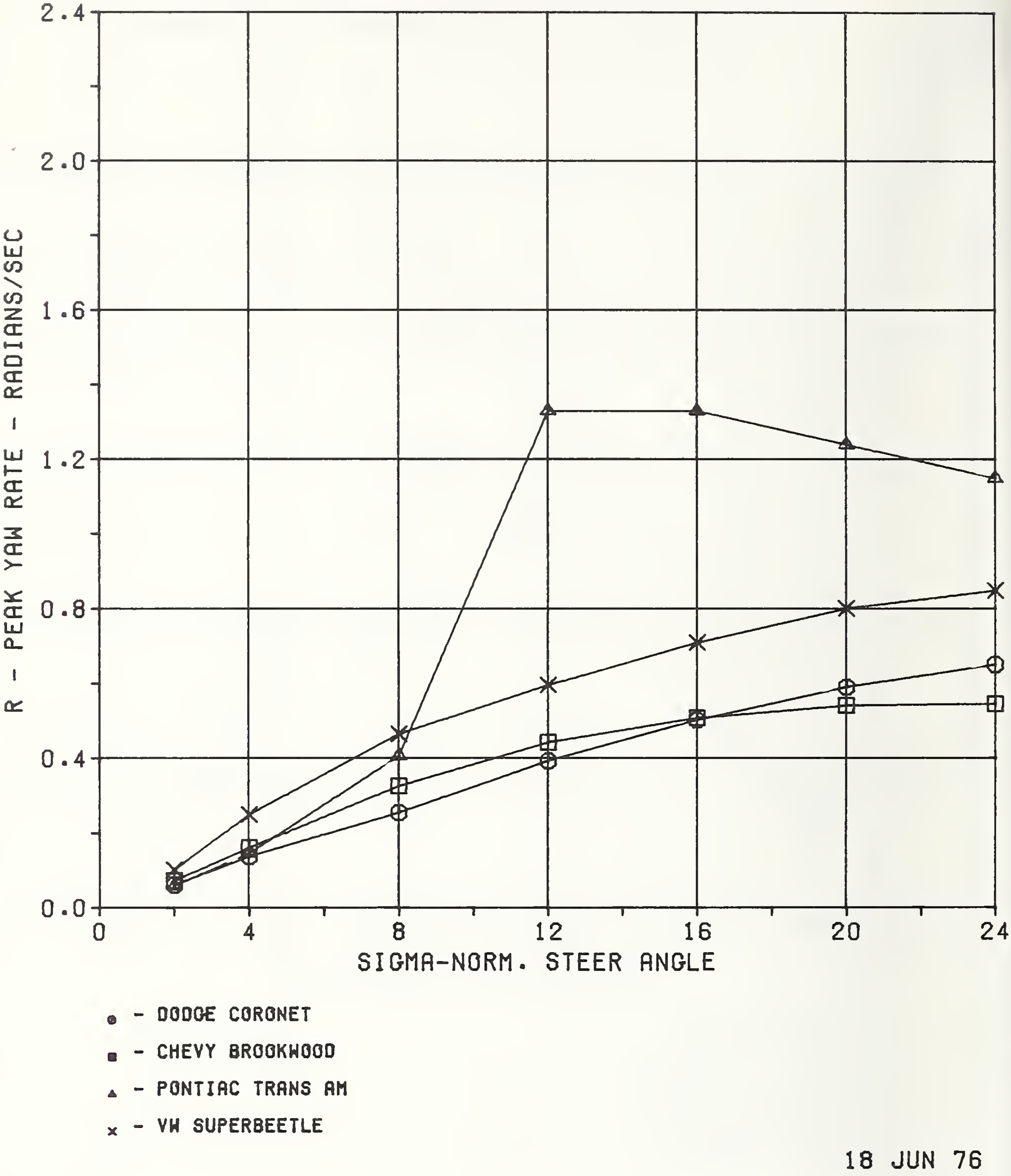


Fig. D-10 VHTP 4, Trapezoidal Steer: Yaw Rate versus Normalized Steer Angle (Calspan, O.E. tires)

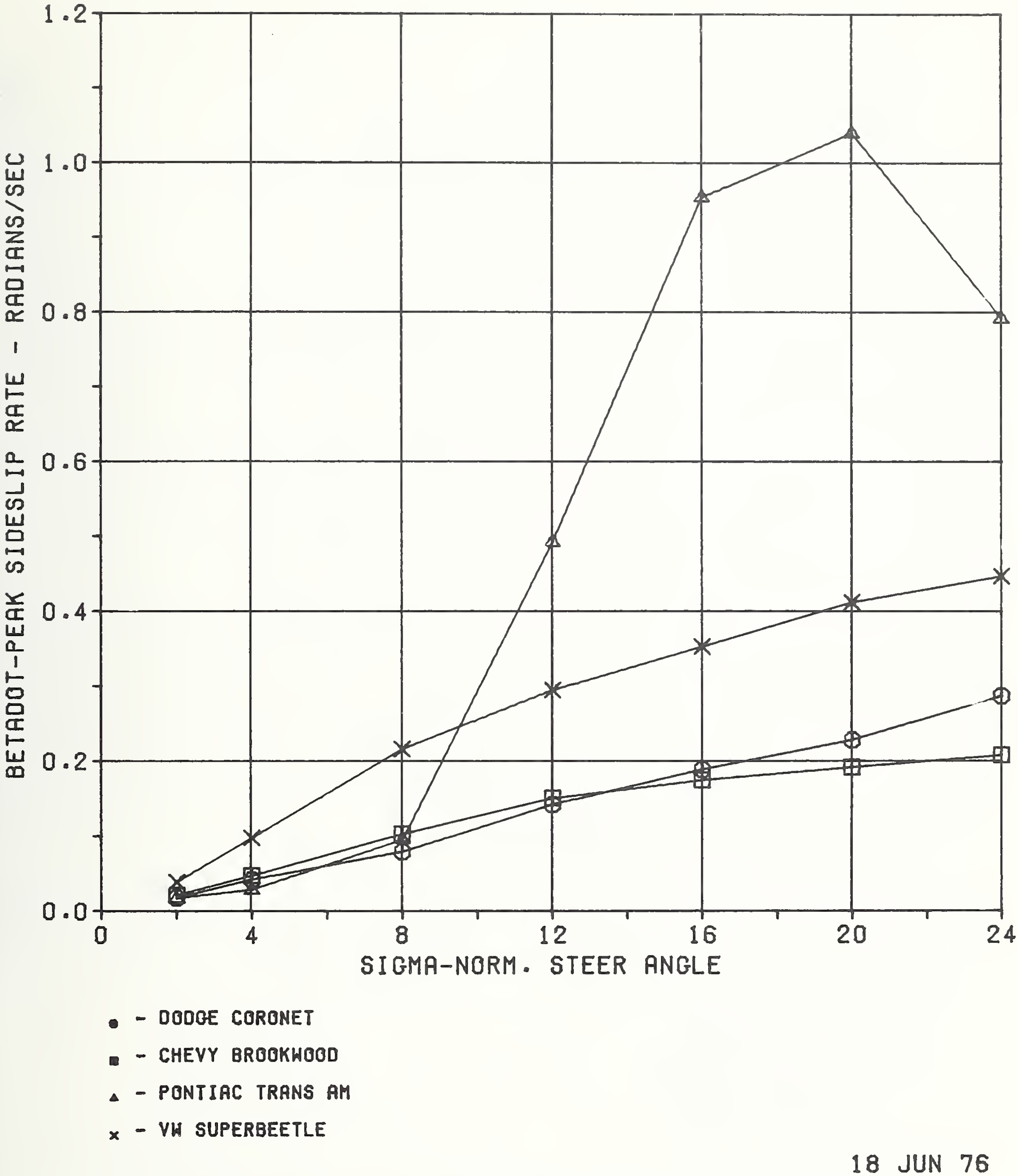


Fig. D-11 VHTP 4, Trapezoidal Steer: Sideslip Rate versus Normalized Steer Angle (Calspan, O.E. tires)

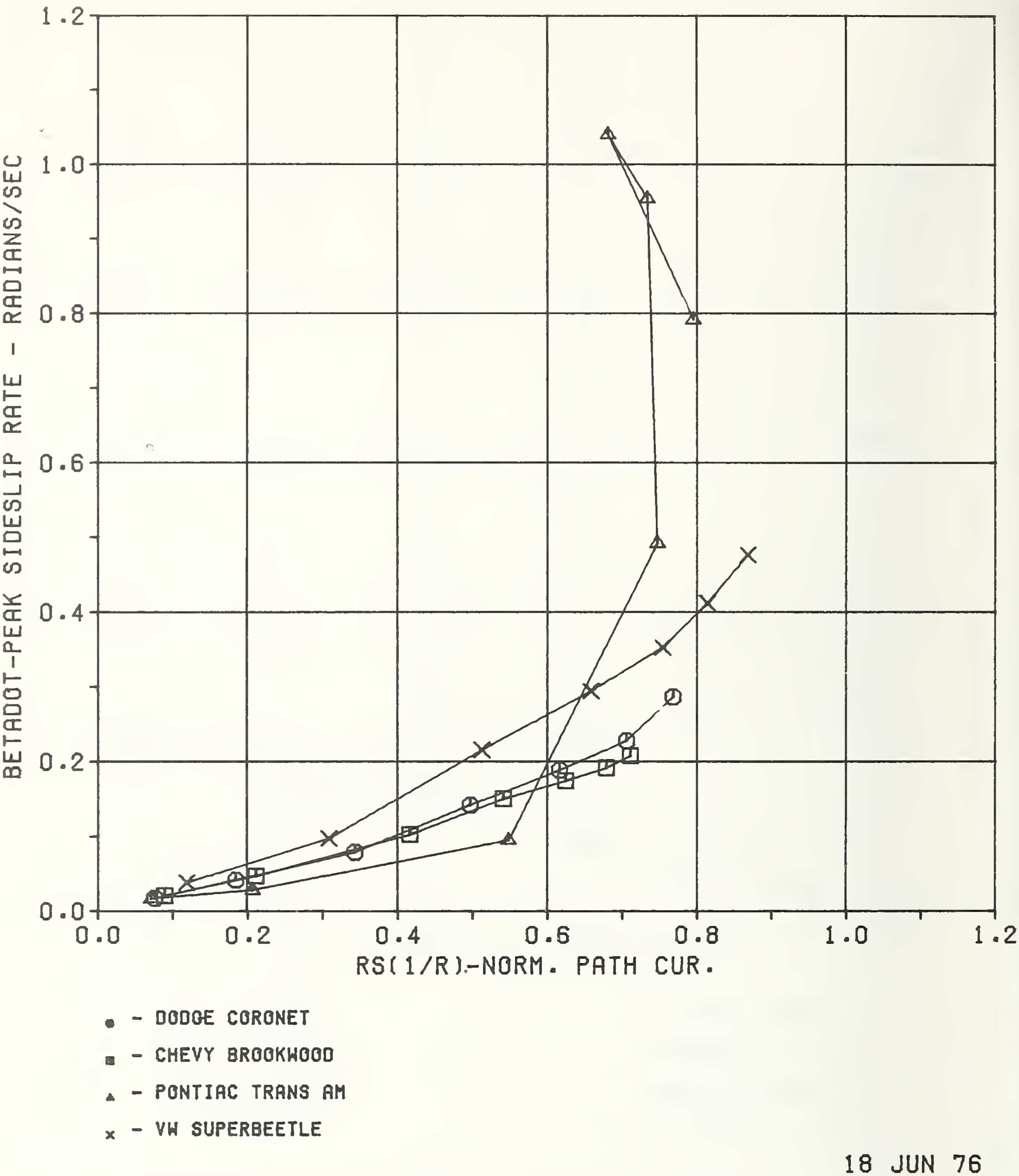


Fig. D-12 VHTP 4, Trapezoidal Steer: Sideslip Rate versus Normalized Path Curvature Ratio (Calspan, O.E. tires)

5. VHPT No. 5: Sinusoidal Steer

DEL PSI — Vehicle heading angle deviation after 3.4 s (rad)

SIGMA — Normalized steer angle (deg)

DEL — Lane change deviation from "IDEAL" lane change displacement (ft)

BETA — Peak vehicle sideslip angle (rad)

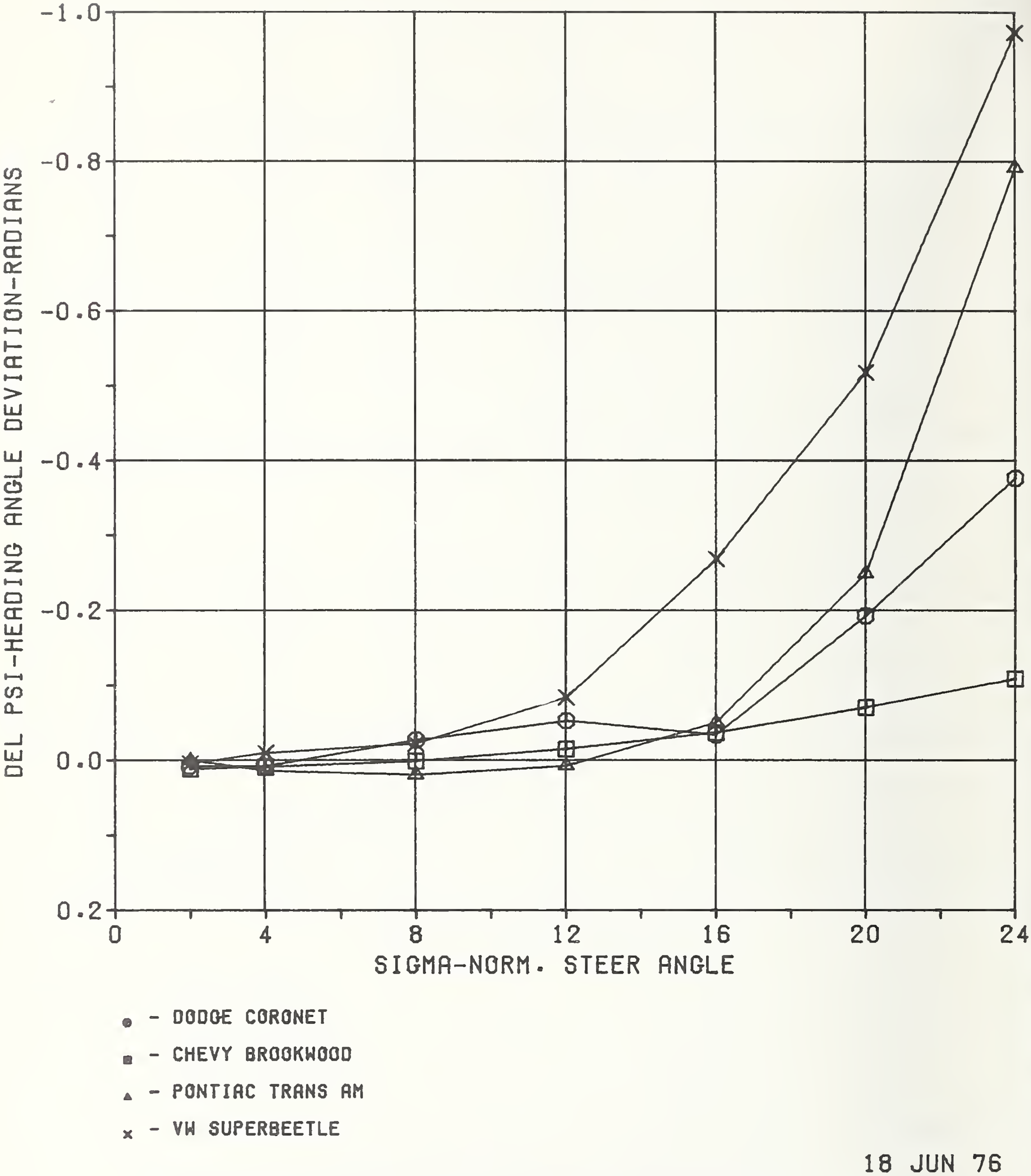


Fig. D-13 VHTP 5, Sinusoidal Steer, 45 mph: Heading Angle Deviation versus Normalized Steer Angle (Calspan, O.E. tires)

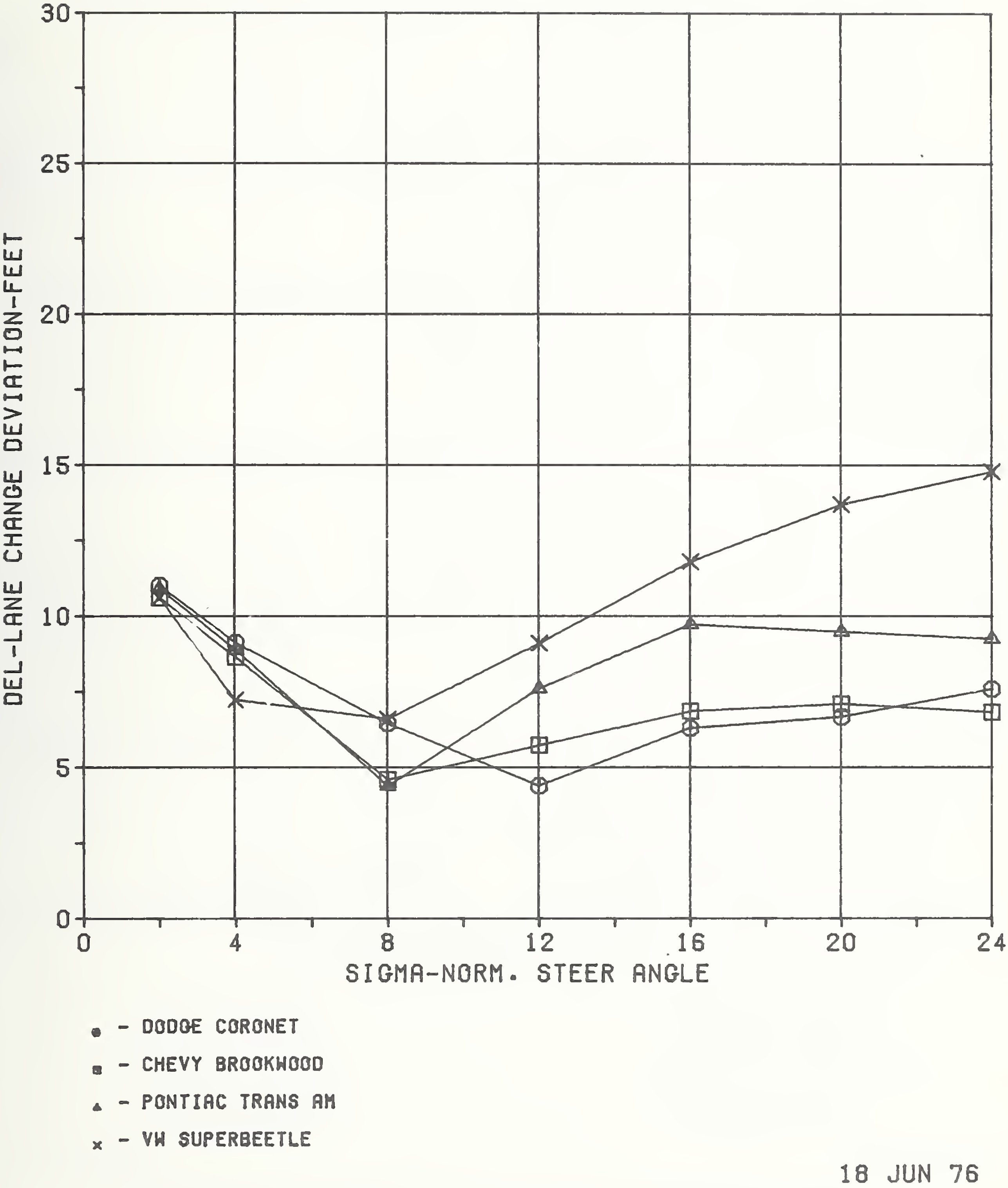


Fig. D-14 VHTP 5, Sinusoidal Steer, 45 mph: Lane Change Deviation versus Normalized Steer Angle (Calspan O.E. tires)

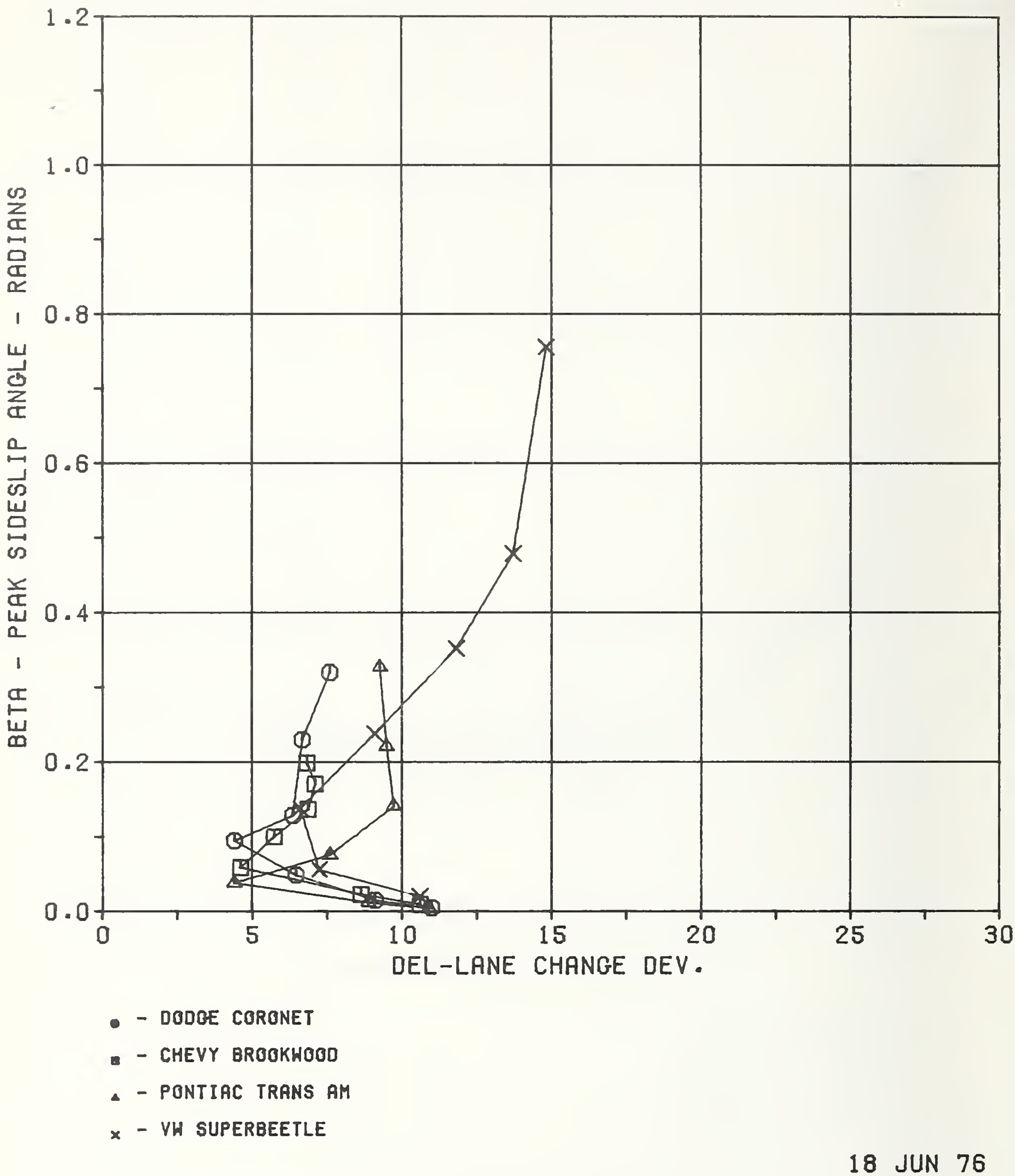


Fig. D-15 VHTP 5, Sinusoidal Steer, 45 mph: Sideslip Angle versus Lane Change Deviation (Calspan, O.E. tires)

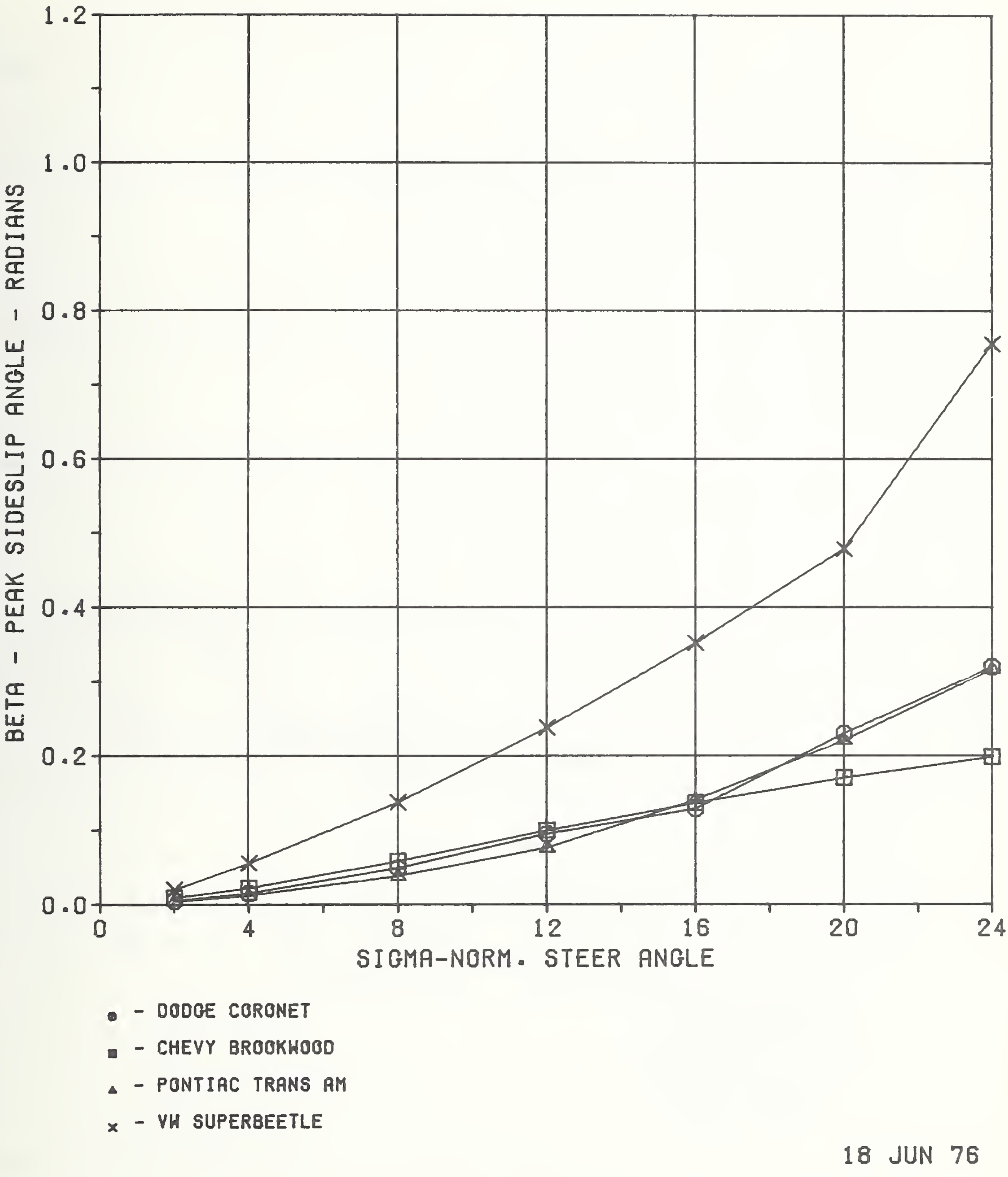


Fig. D-16 VHTP 5, Sinusoidal Steer, 45 mph: Sideslip Angle versus Normalized Steer Angle (Calspan, O.E. tires)

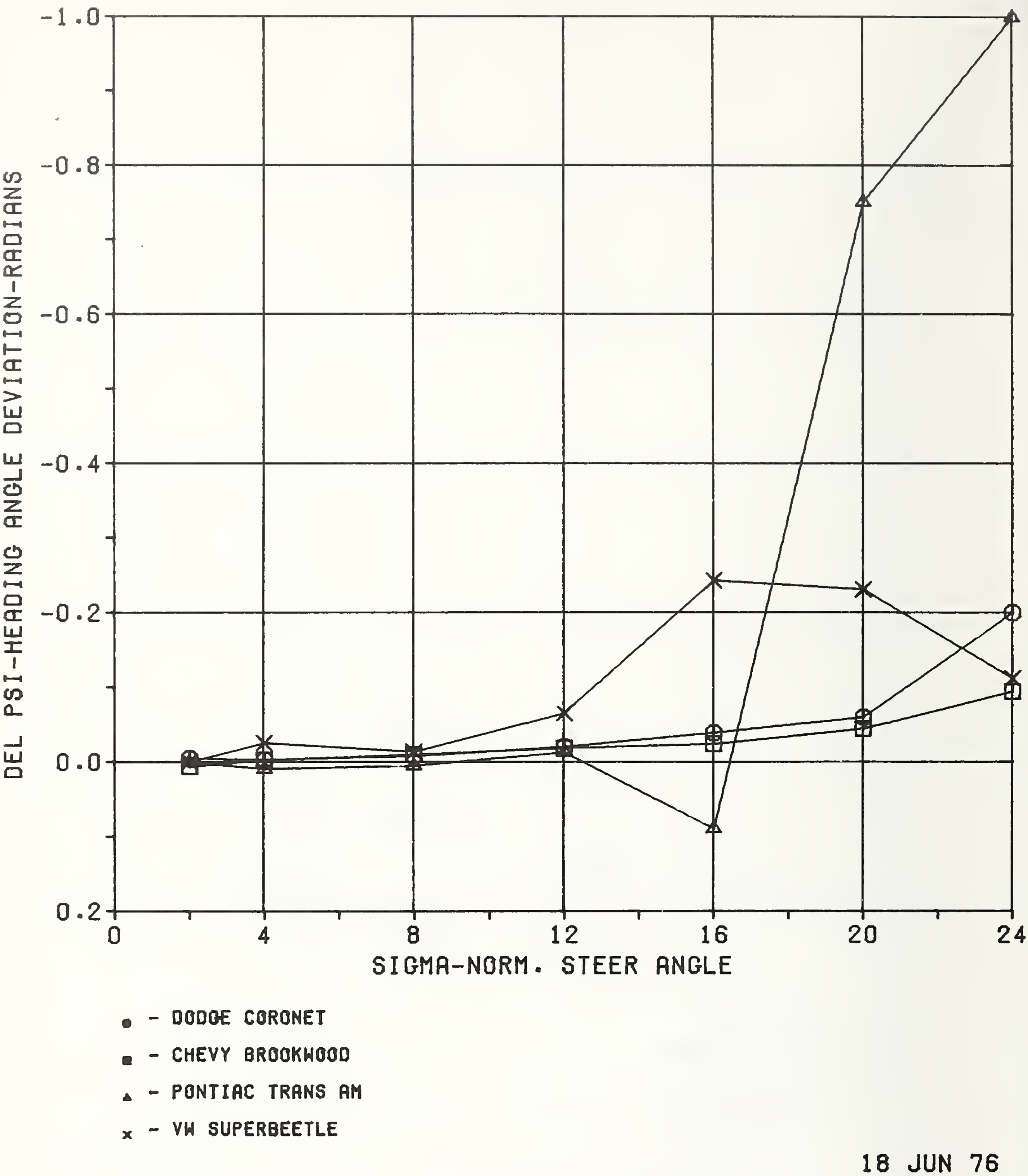


Fig. D-17 VHTP 5, Sinusoidal Steer, 60 mph: Heading Angle Deviation versus Normalized Steer Angle (Calspan, O.E. tires)

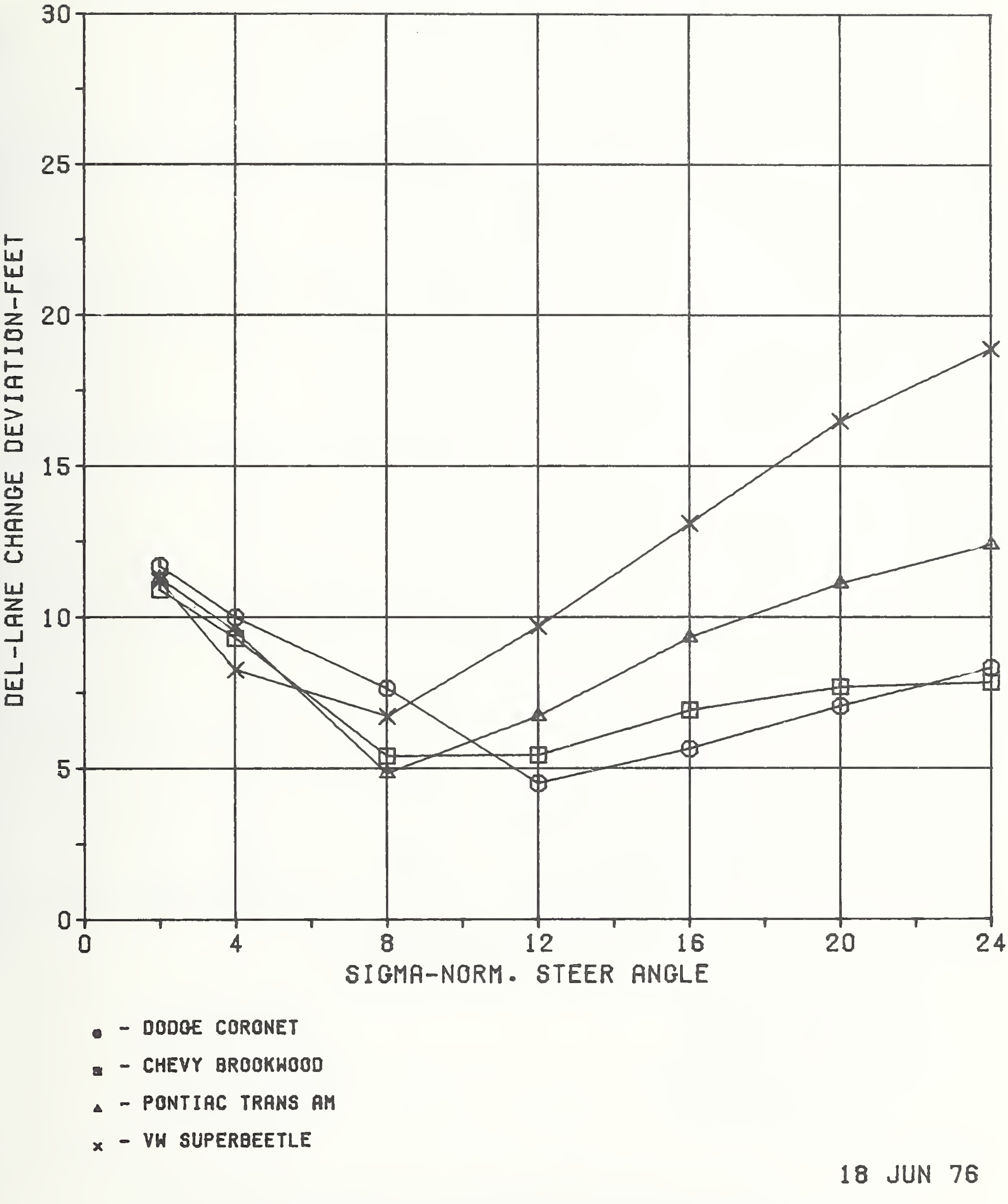


Fig. D-18 VHTP 5, Sinusoidal Steer, 60 mph: Lane Change Deviation versus Normalized Steer Angle (Calspan, O.E. tires)

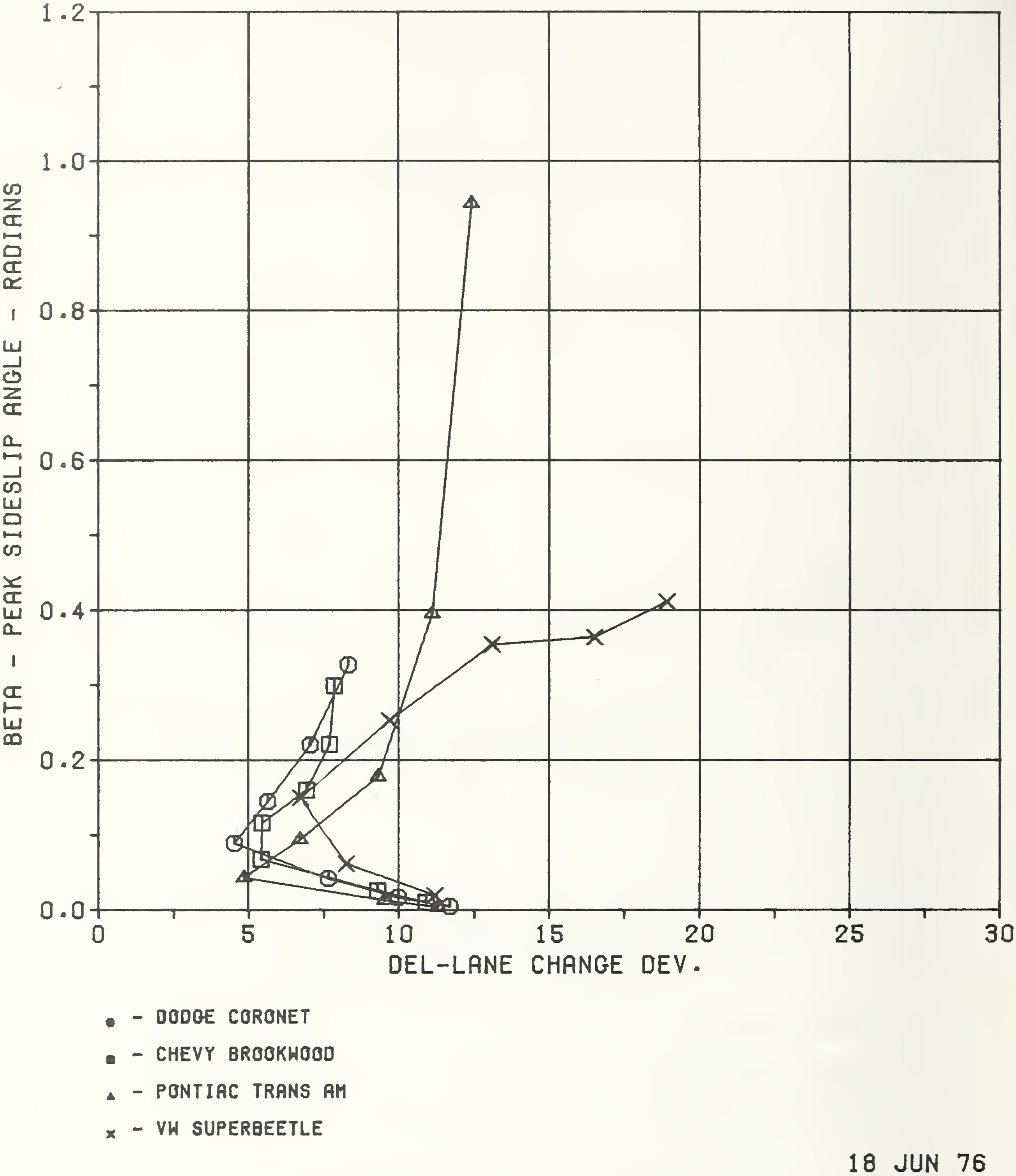


Fig. D-19 VHTP 5, Sinusoidal Steer, 60 mph: Sideslip Angle versus Lane Change Deviation (Calspan, O.E. tires)

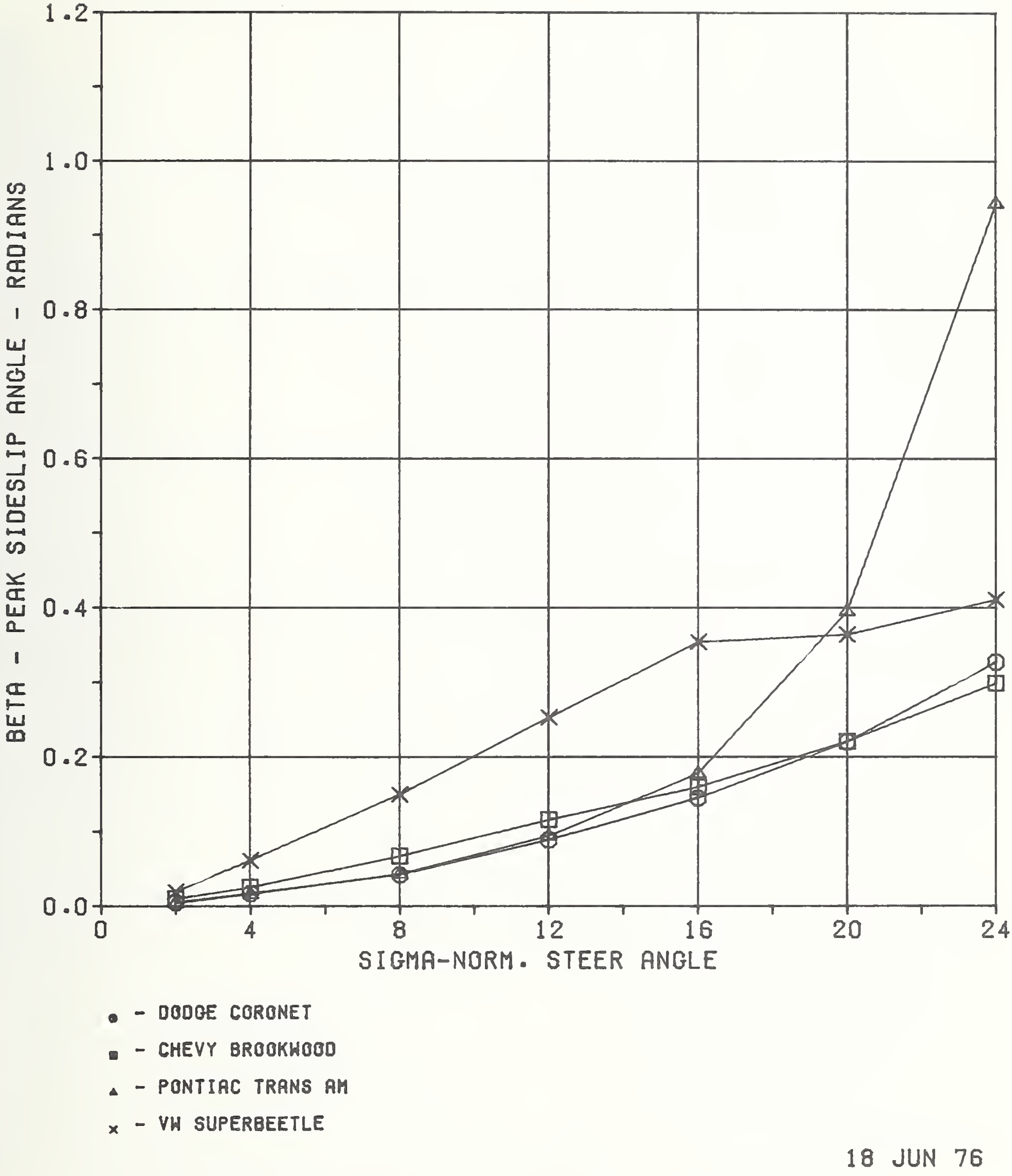


Fig. D-20 VHTP 5, Sinusoidal Steer, 60 mph: Sideslip Angle versus Normalized Steer Angle (Calspan, O.E. tires)

6. VHTP No. 6: Drastic Steer and Brake

PHI — Peak roll angle (rad)

PHIDOT — Peak roll angle rate (rad/s)

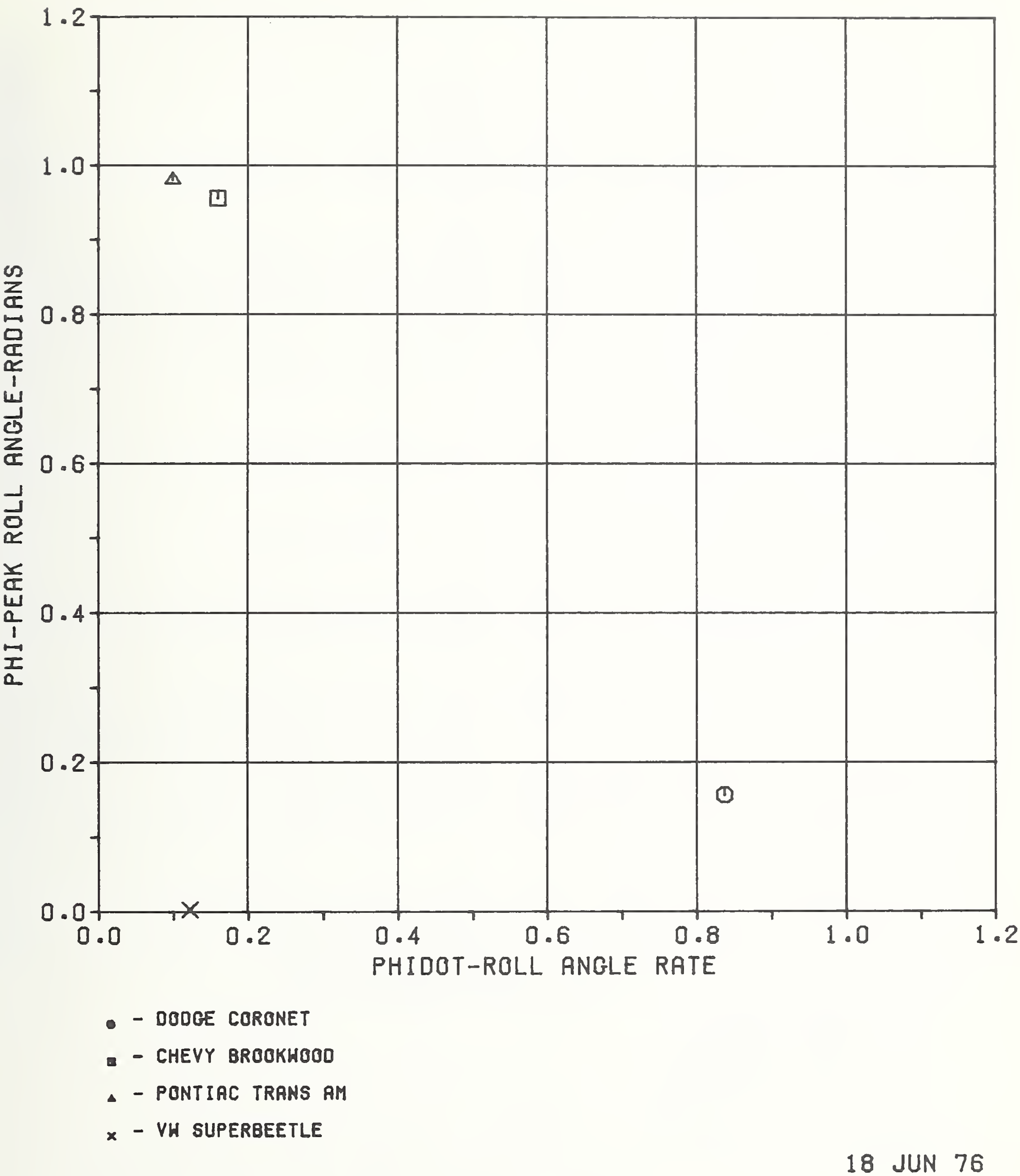


Fig. D-21 VHTP 6, Drastic Steer and Brake, 50 mph: Roll Angle versus Roll Angle Rate (Calspan, O.E. tires)

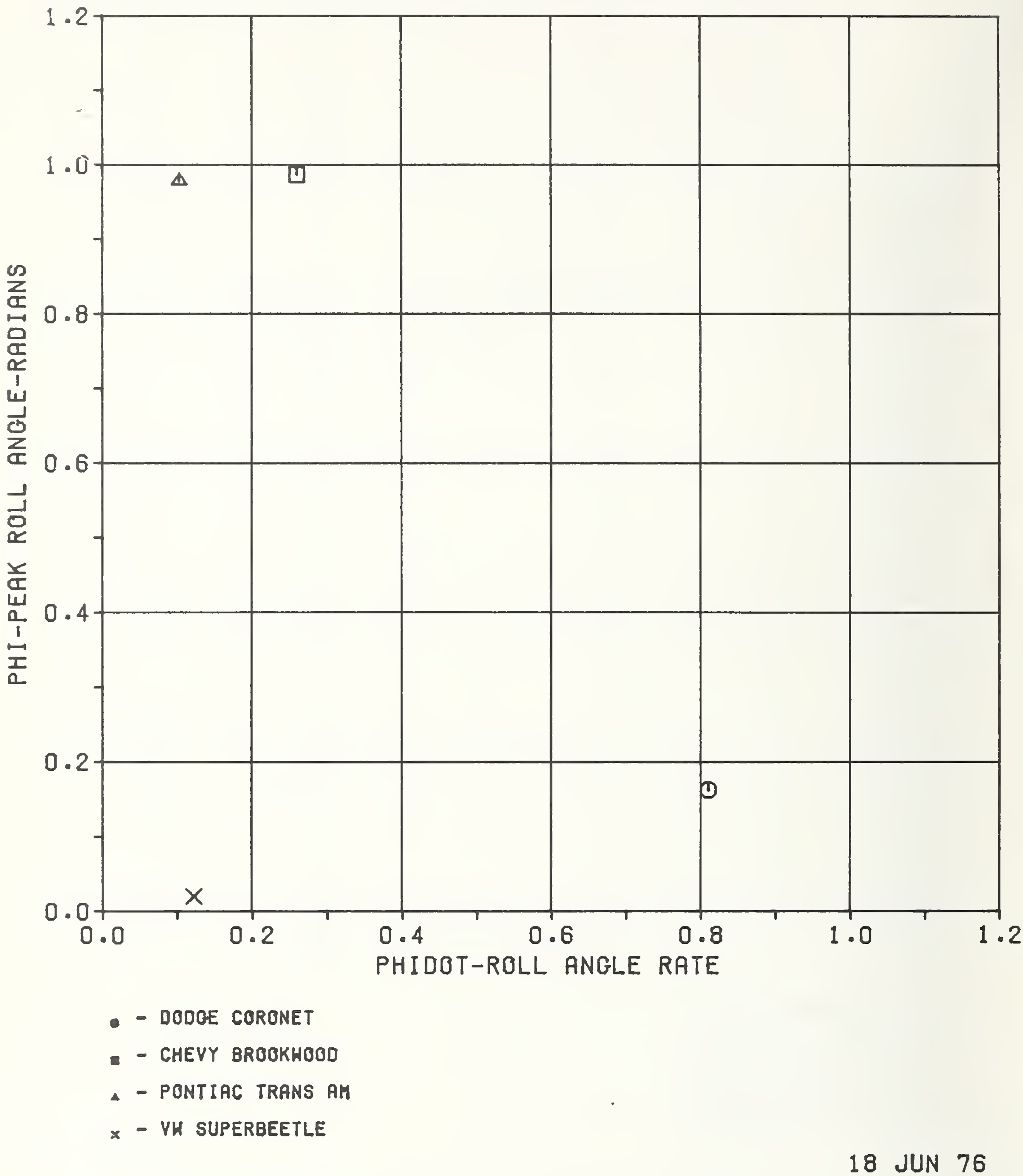


Fig. D-22 VHTP 6, Drastic Steer and Brake, 60 mph: Roll Angle versus Roll Angle Rate (Calspan, O.E. tires)

Appendix E

SIMULATION OUTPUT

In addition to the user/computer transactions printed on the hybrid computer operator's printer, the simulation has several outputs that are normally available to the user. The output is summarized below:

1. Vehicle Handling Test Procedure (VHTP) comparison variable values,

2. Analog strip chart time history recordings (16 variables),

3. Digital printout of variables versus time (up to 50 variables),

4. Comparison variable graphs, and

5. X-Y printer plot of any two program variables.

The appropriate VHTP comparison variable values are printed following the execution of a VHTP maneuver. Typical examples are presented in Fig. E-1.

Sixteen channels of strip chart time history recordings are available. Time histories for the braking in a turn test procedure are presented in Fig. E-2. The variables are defined below:

Figure E-2, p. 1:

1. Longitudinal deceleration, A_x (g),

2. Lateral acceleration, A_y (g),

3. Vehicle yaw rate, r (rad/s),

4. Steering wheel input, δ_{sw} (rad),

5. Vehicle forward velocity, u (ft/s),

6. Vehicle side velocity, v (ft/s),

7. Vehicle sideslip angle, β (rad), and

8. Turning radius of curvature, 1/R (ft^{-1}).

```
**********    THIS IS THE FIRST OF TWO SPECIAL CARDS FOR THE 2741 ACM  *********
        VEHICLE HANDLING SIMULATION
ENGAGE PATCH PANEL FOR TEST
TYPE CR WHEN READY
****
MAY        21  1974
TIME  14. 0 11.76
OPTION
****  F
ENTER
****  VHTPNO 4
****
OPTION
****  IC
OPTION
****  F
ENTER
****  STR4
   27.90
****  STR4 300.
****
OPTION
****  X
MAY        21  1974
TIME  14. 2. 7.18
RUN   1 HAS STARTED
OUTPUT BELOW
 AXAV=   0.0   DECL TIME=   0.000 AVCUR=   0.981 BTDMAX=   0.210 BTMAX=   0.126 DELBT=   0.126
AYMAX=   0.945 PHIMAX=   4.101 RMAX=   0.708 LANE CHNG DEL=   0.0   DELPSI=   0.0   MAX STEER= 300.000
FTRQMAX=   0.0   RTRQMAX=   0.0

OPTION
****  F
ENTER
****  VHTPNO
   4.000
****
OPTION
****  MULTI
NUM OF LOOPS/VARS
****  4 1
VAR
****  STR4
LOOP/VAL/INC
****  1 27.9 27.9
****
OPTION
****  XM
MAY        21  1974
TIME  14. 4 16.24
RUN   2 HAS STARTED
OUTPUT BELOW
MULTI TOTAL STR4..(   1) BETAMX(   1) BETDMX(   1) CUVRAT(   1) AYMAX.(   1) RMAX..(   1)
  1     2       27.9       0.315E-02     0.208E-01     0.928E-01     0.134        0.694E-01
  2     3       55.8       0.105E-01     0.341E-01     0.260         0.342        0.186
  3     4       83.7       0.219E-01     0.646E-01     0.428         0.539        0.304
  4     5       112.       0.375E-01     0.909E-01     0.573         0.691        0.409
OPTION
```

Fig. E-1 IHVHP User's Interactive Control

Fig. E-2 Time Histories — Braking in a Turn (p. 1)

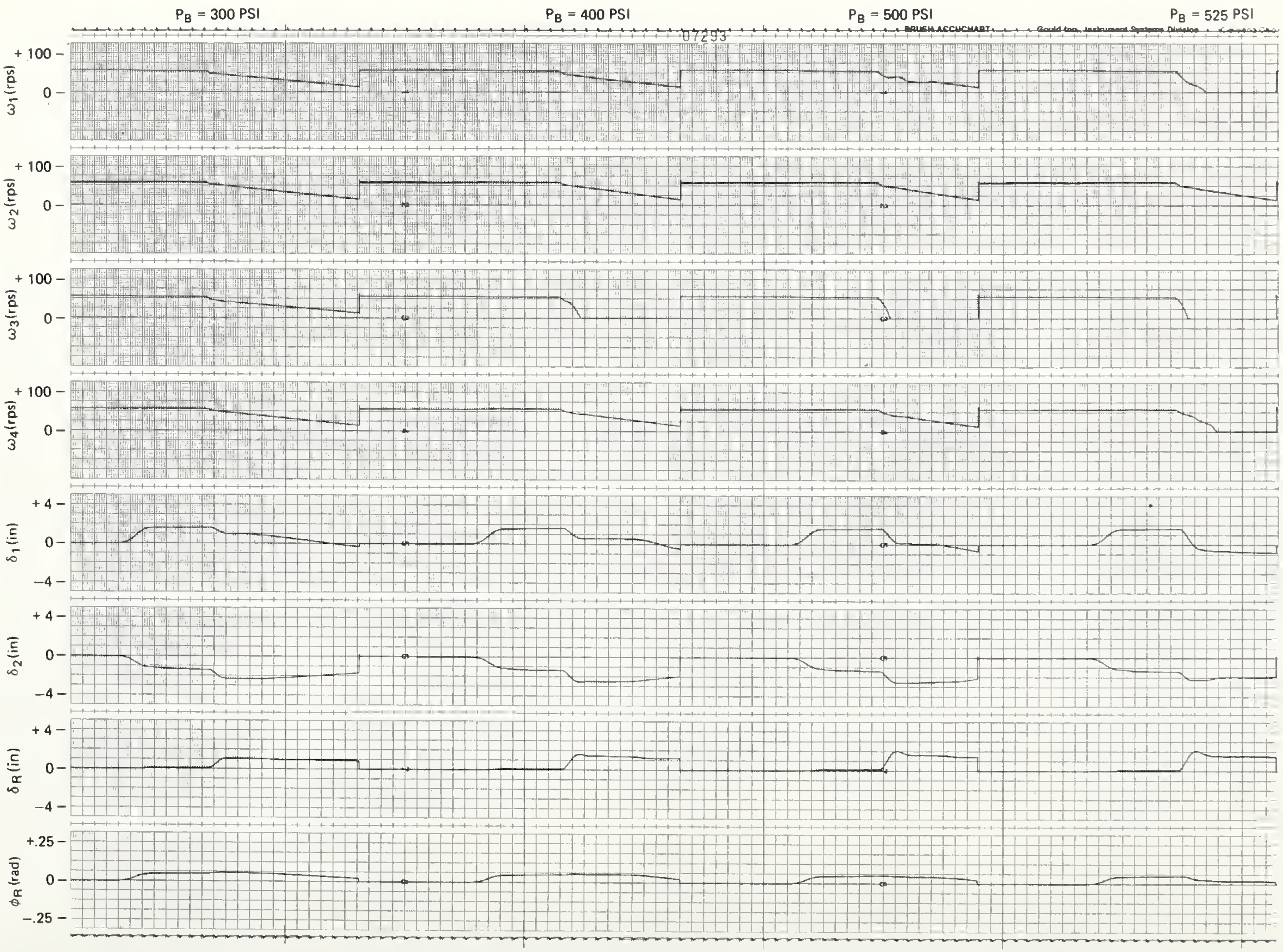


Fig. E-2 Time Histories — Braking in a Turn (p. 2)

Figure E-2, p. 2:

1-4 Angular velocities of the right front, left front, right rear, and left rear wheels, ω_1, ω_2, ω_3, ω_4, respectively, (rad/s),

5-7 Deflection from the equilibrium position of the right front wheel, left front wheel, and rear axle, δ_1, δ_2, δ_R, respectively (in.), and

8 Angular rotation of the rear axle with reference to the sprung mass, ϕ_r (rad).

The digital printout of variables versus time is the typical output associated with digital simulation. The variables to be output can be specified in the program data deck or selected interactively during program execution. The time interval for output is also interactively selected. The interactive selection capability is particularly useful for simulation validation or studying unexpected dynamic phenomena. Any variable within the simulation can be selected for output. An output example is presented in Fig. E-3.

```
OPTION
****  TRACK
UNIT,MODE
****  T A
ENTER TIME ON,OFF,STEP
****  .5 1.1 .1
TYPE RETAIN OR ENTER NEW ARRAY
****  PSIDT PHIDT PHI ZIMX(1) ZIMX(3)
****
```

TIME	PSIDT.(1)	PHIDT.(1)	PHI...(1)	ZIMX..(1)	ZIMX..(3)
0.50	0.43077	0.77597E-02	-0.11728	0.29986E-01	0.10125
0.60	0.35703	0.29683	-0.10414	0.29986E-01	0.10125
0.70	0.28586	0.49151	-0.59047E-01	0.29986E-01	0.10125
0.80	0.28740	0.32454	-0.16426E-01	0.29986E-01	0.10125
0.90	0.30123	0.14344E-02	-0.12279E-03	0.29986E-01	0.10125
1.00	0.28316	-0.14820	-0.90558E-02	0.29986E-01	0.10125
1.10	0.29048	-0.38197	-0.30314E-01	0.29986E-01	0.10125

```
OPTION
```

Fig. E-3 Digital Line Printer Output

To aid in quick analysis of vehicle performance, computer-generated comparison variable plots are made available. An example plot for a trapezoidal steer test procedure is presented in Fig. E-4.

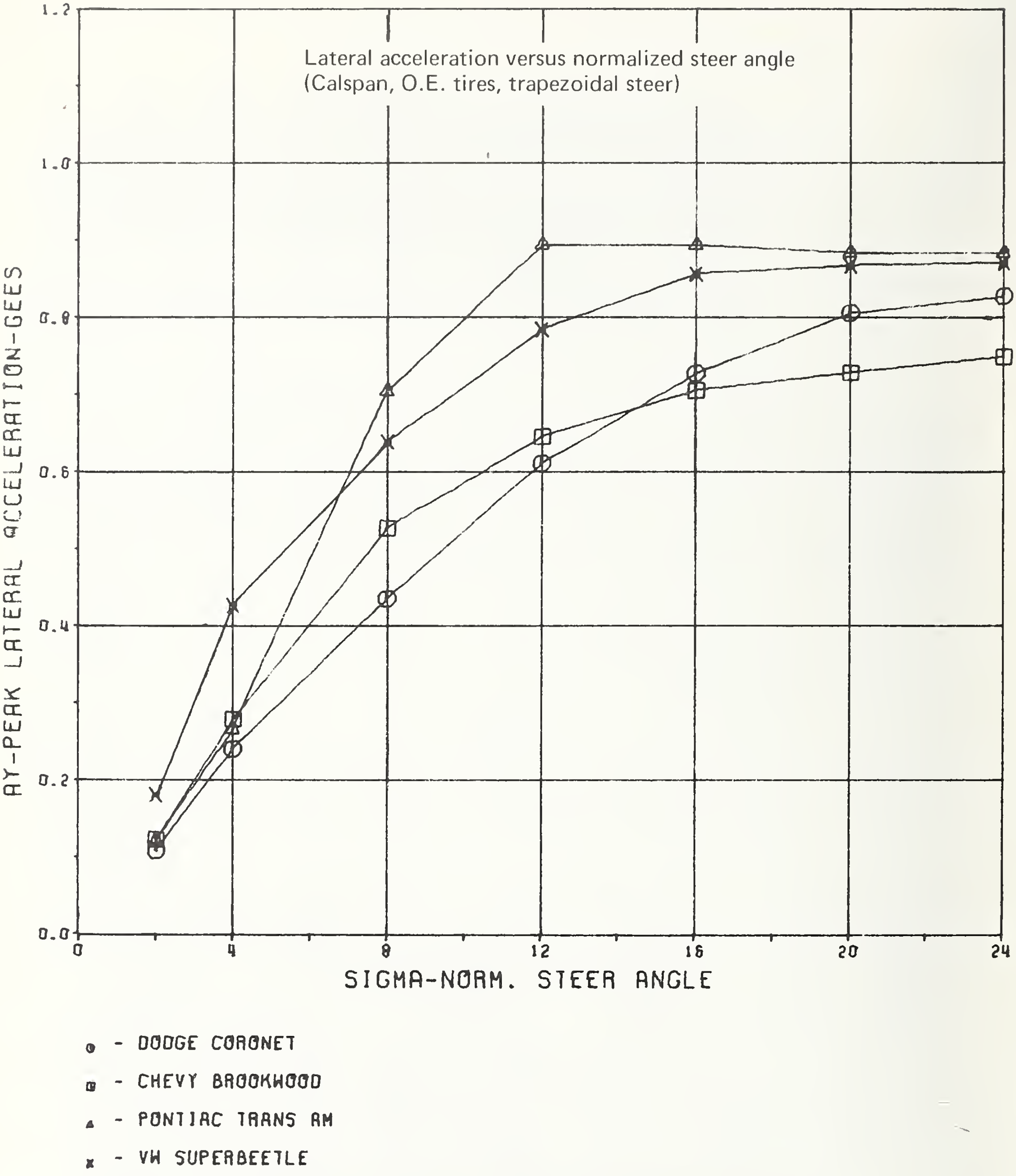


Fig. E-4 Performance Comparison Variable Plot

A cross-plot of any two interactive variables that are included in the TRACK option is available to the simulation user. An example of the PLOT option and of the required input data is shown below. Figure E-5 is a vehicle trajectory plot.

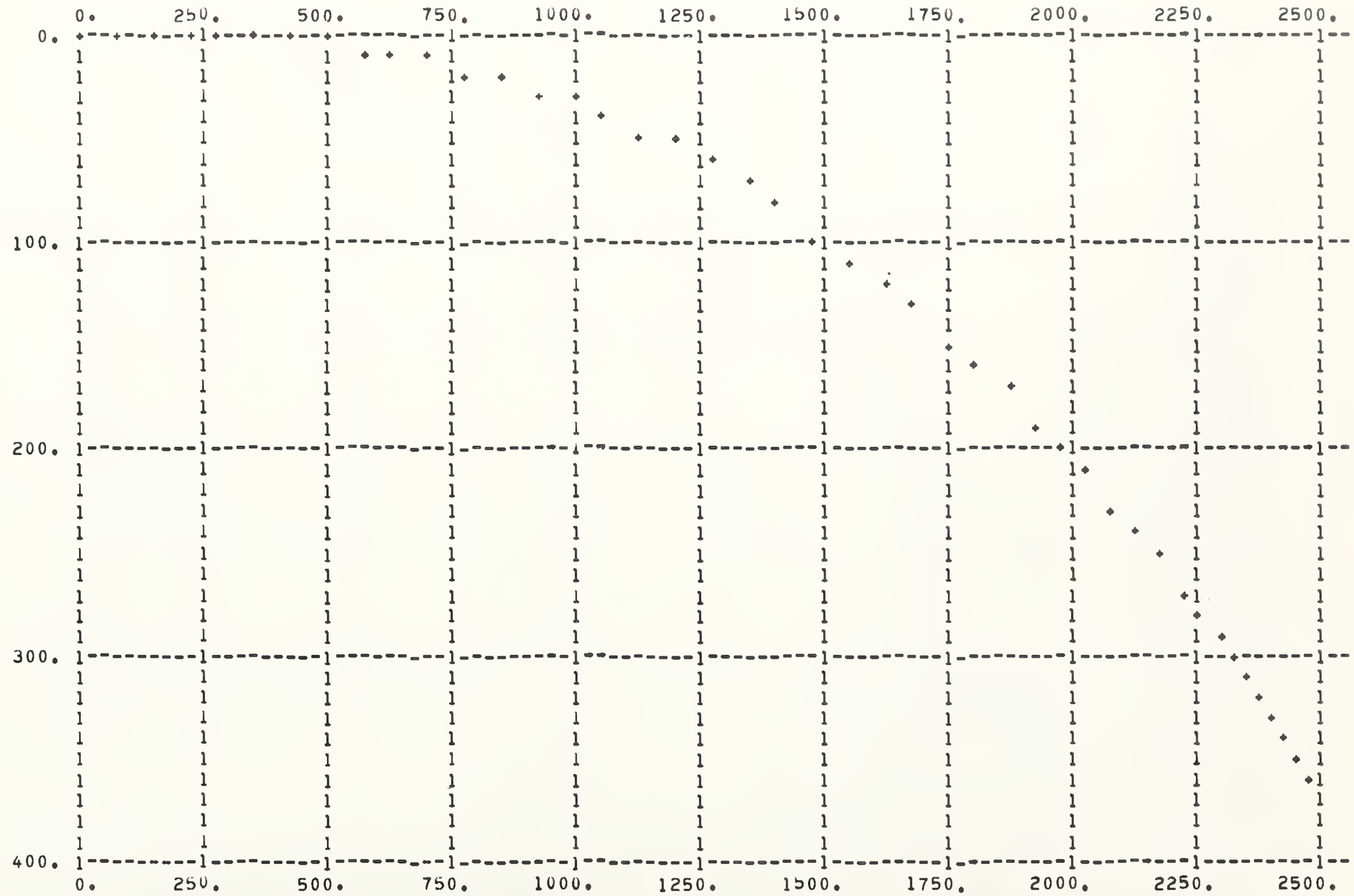
```
OPTION
****  PLOT
UNIT,MODE
****  L XEQ
ENTER NUMBER OF PLOTS
****  1
ENTER DEPENDENT AND INDEPENDENT PLOT VARIABLES
****  Y X
****
OPTION
```

Y....... VS X.......

DATE: 1/20/78

**** X....... ****

Y*E+2	X*E+3
0.042	0.497
0.121	0.708
0.206	0.848
0.320	0.989
0.389	1.059
0.549	1.199
0.640	1.269
0.739	1.338
0.846	1.408
0.959	1.477
1.078	1.545
1.203	1.613
1.331	1.679
1.462	1.743
1.596	1.805
1.730	1.865
1.866	1.922
2.001	1.977
2.135	2.030
2.267	2.079
2.398	2.126
2.527	2.171
2.653	2.213
2.775	2.252
2.893	2.288
3.007	2.322
3.116	2.354
3.219	2.383
3.317	2.410
3.407	2.434
3.490	2.455
3.567	2.474



OPPOSITE AXIS LABEL **** Y....... ****

Fig. E-5 X-Y Line Printer Plot

Appendix F

TIRE FUNCTION GRAPHS

Figures F-1 through F-15 are the graphs used to validate the tire model output for a set of tire parameters. The figures are followed by a copy of the information available from Ref. 19 for a particular tire. The parameters from this data packet were used to generate the figures.

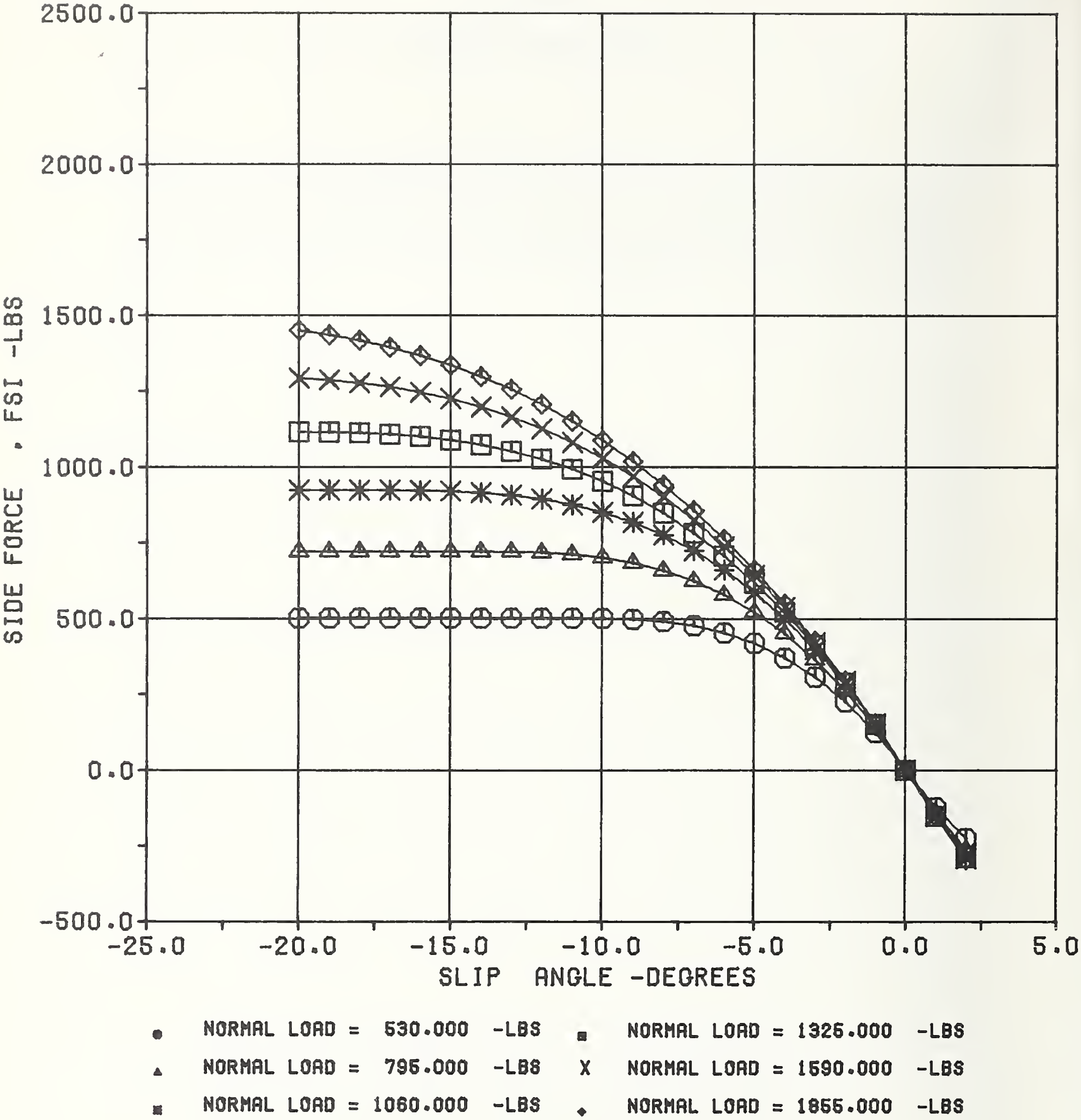
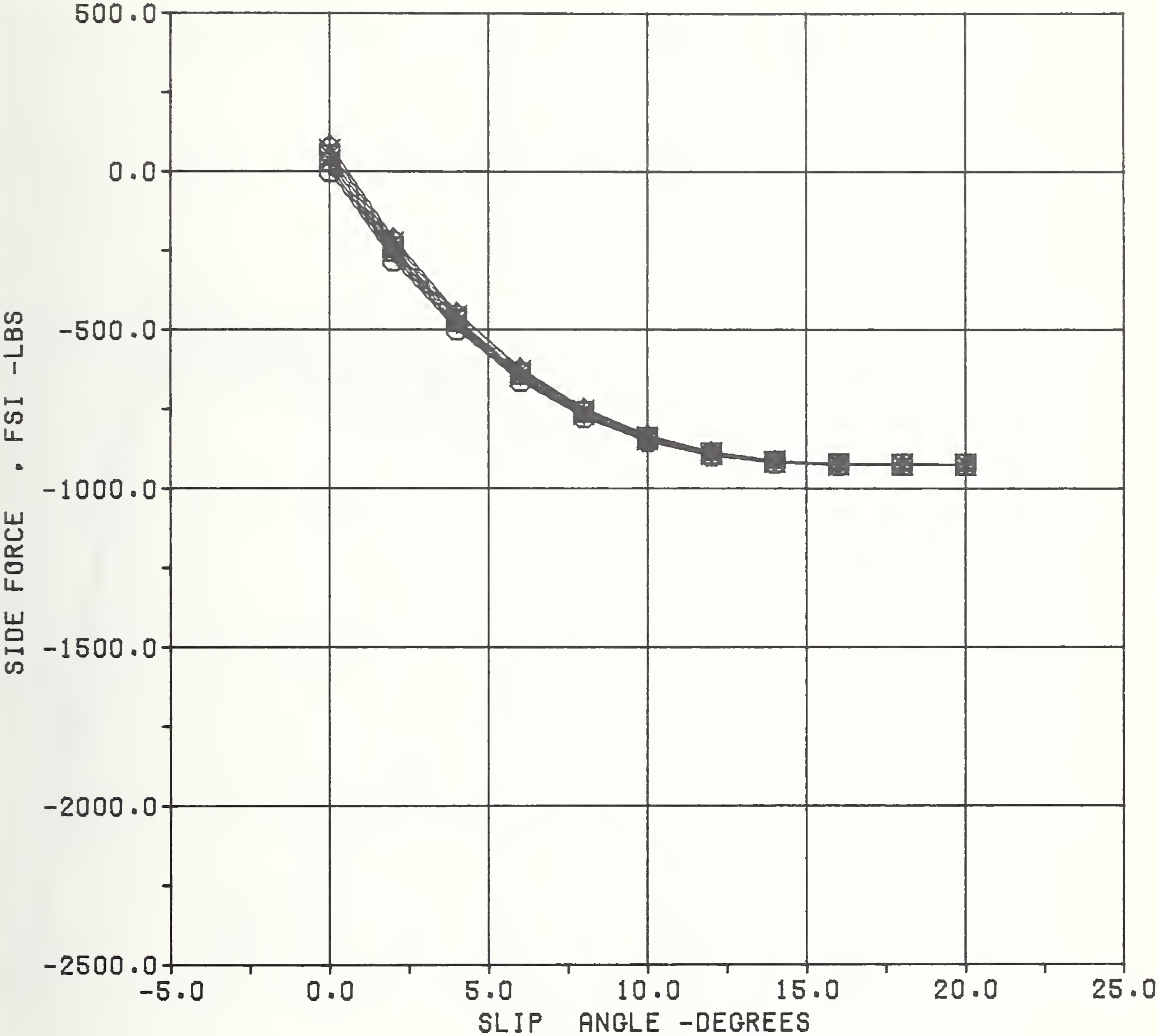


Fig. F-1 Side Force versus Slip Angle with Normal Load Varying, 8 May 1978
(235 185-14X MI R XWW, camber = 0., slip = 0.)



● CAMBER ANGLE= 0.0 DEGREES ■ CAMBER ANGLE= 6.000 DEGREES
▲ CAMBER ANGLE= 2.000 DEGREES X CAMBER ANGLE= 8.000 DEGREES
■ CAMBER ANGLE= 4.000 DEGREES ◆ CAMBER ANGLE= 10.000 DEGREES

Fig. F-2 Side Force versus Slip Angle with Camber Angle Varying, 8 May 1978
(235 185-14X MI R XWW, load = 1060. lbs., slip = 0.)

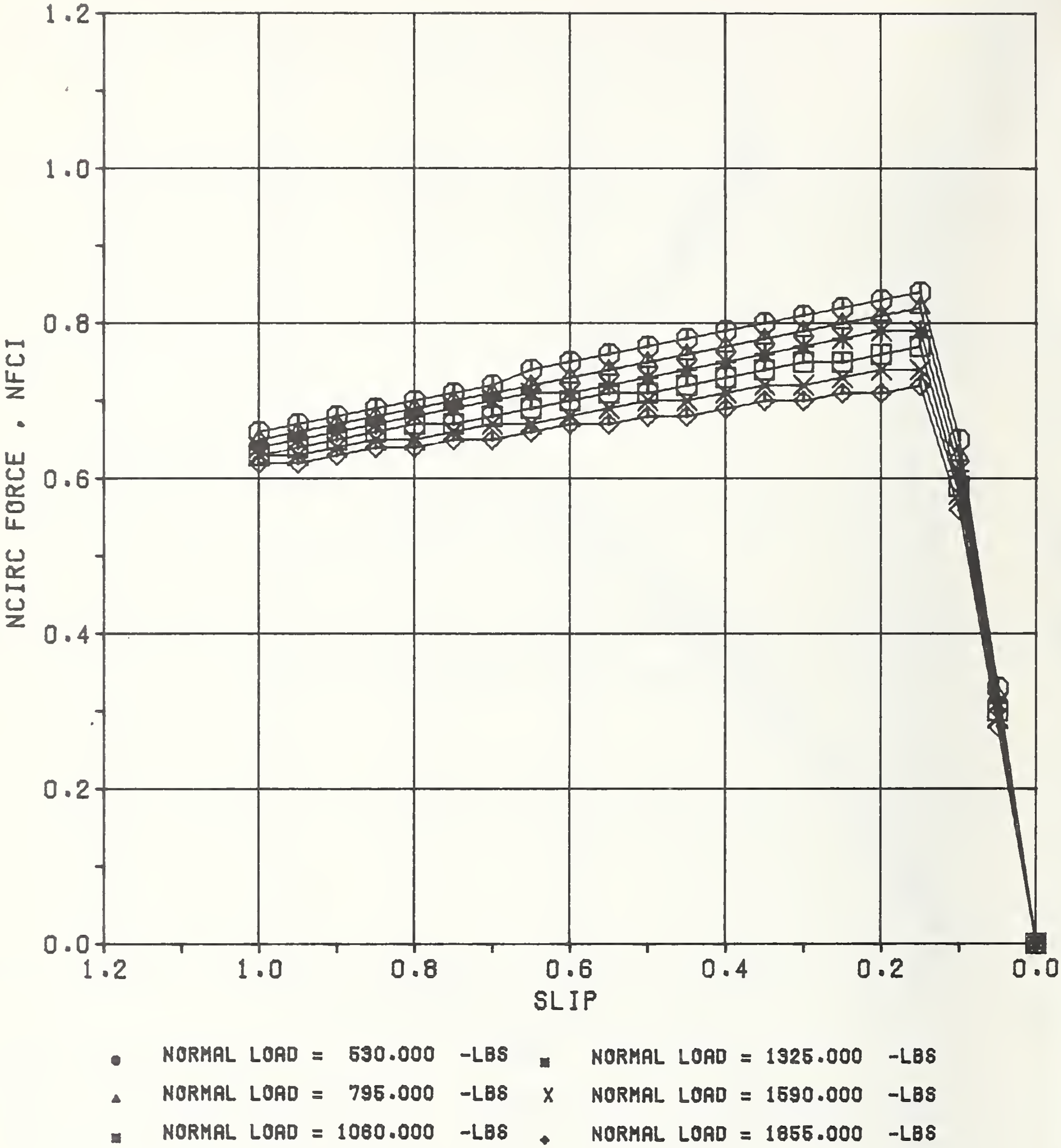


Fig. F-3 NCIRC Force versus Slip with Normal Load Varying, 8 May 1978 (235 185-14X MI R XWW, slip angle = 0., camber = 0.)

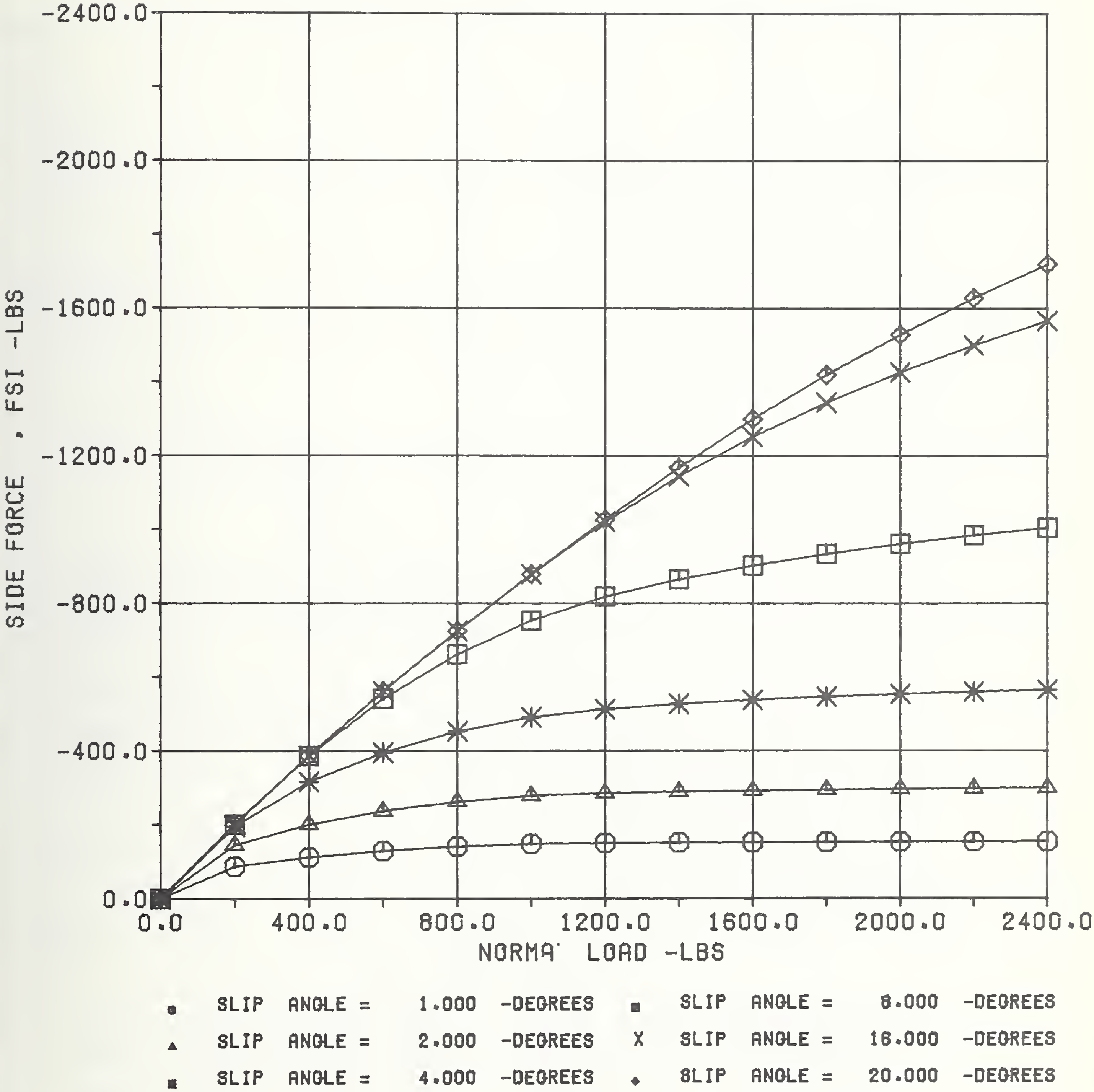


Fig. F-4 Side Force versus Normal Load with Slip Angle Varying, 4 May 1978
(235 185-14X MI R XWW, camber = 0., slip = 0.)

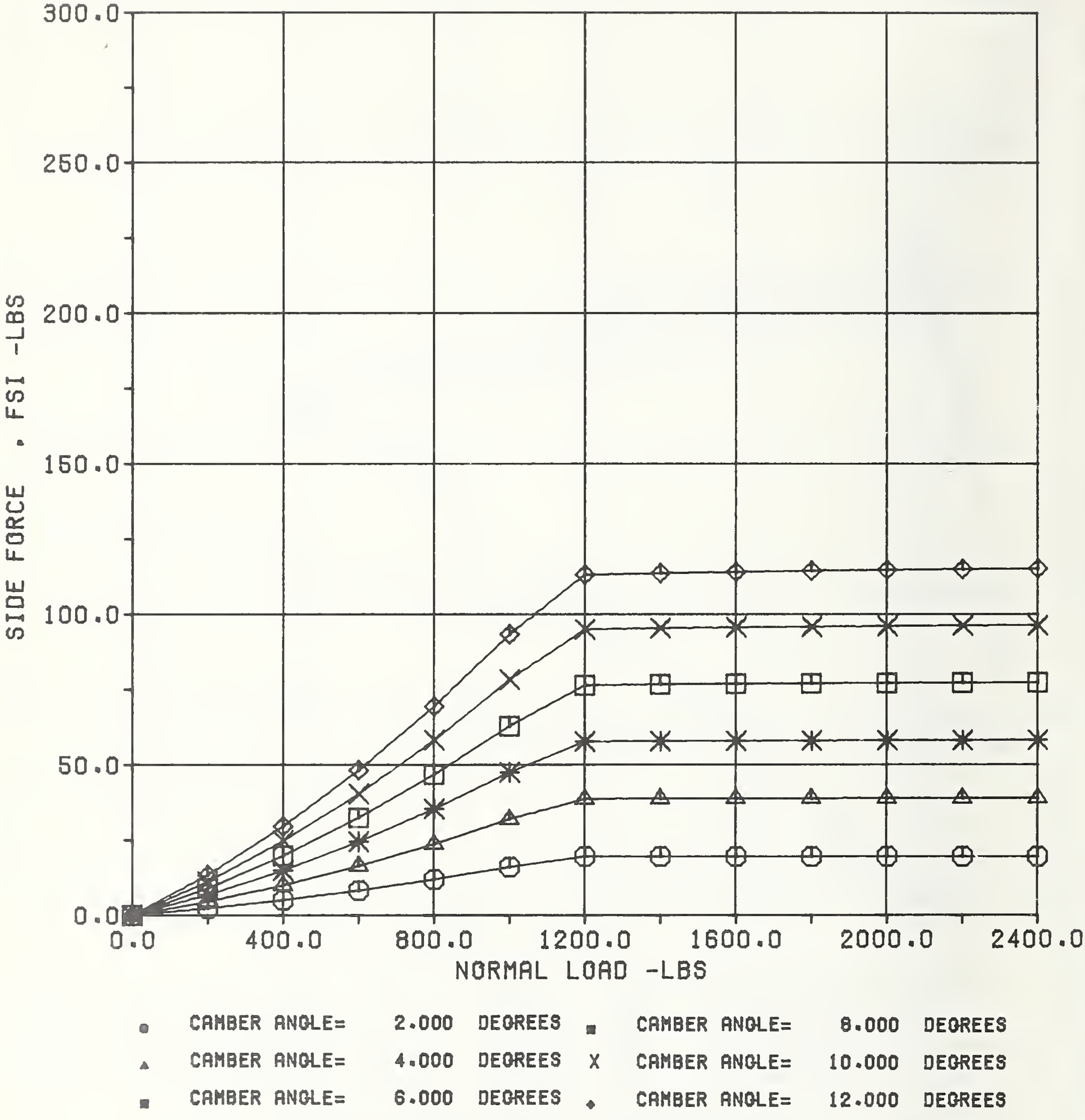


Fig. F-5 Side Force versus Normal Load with Camber Angle Varying, 5 May 1978
(235 185-14X MI R XWW, slip angle = 0., slip = 0.)

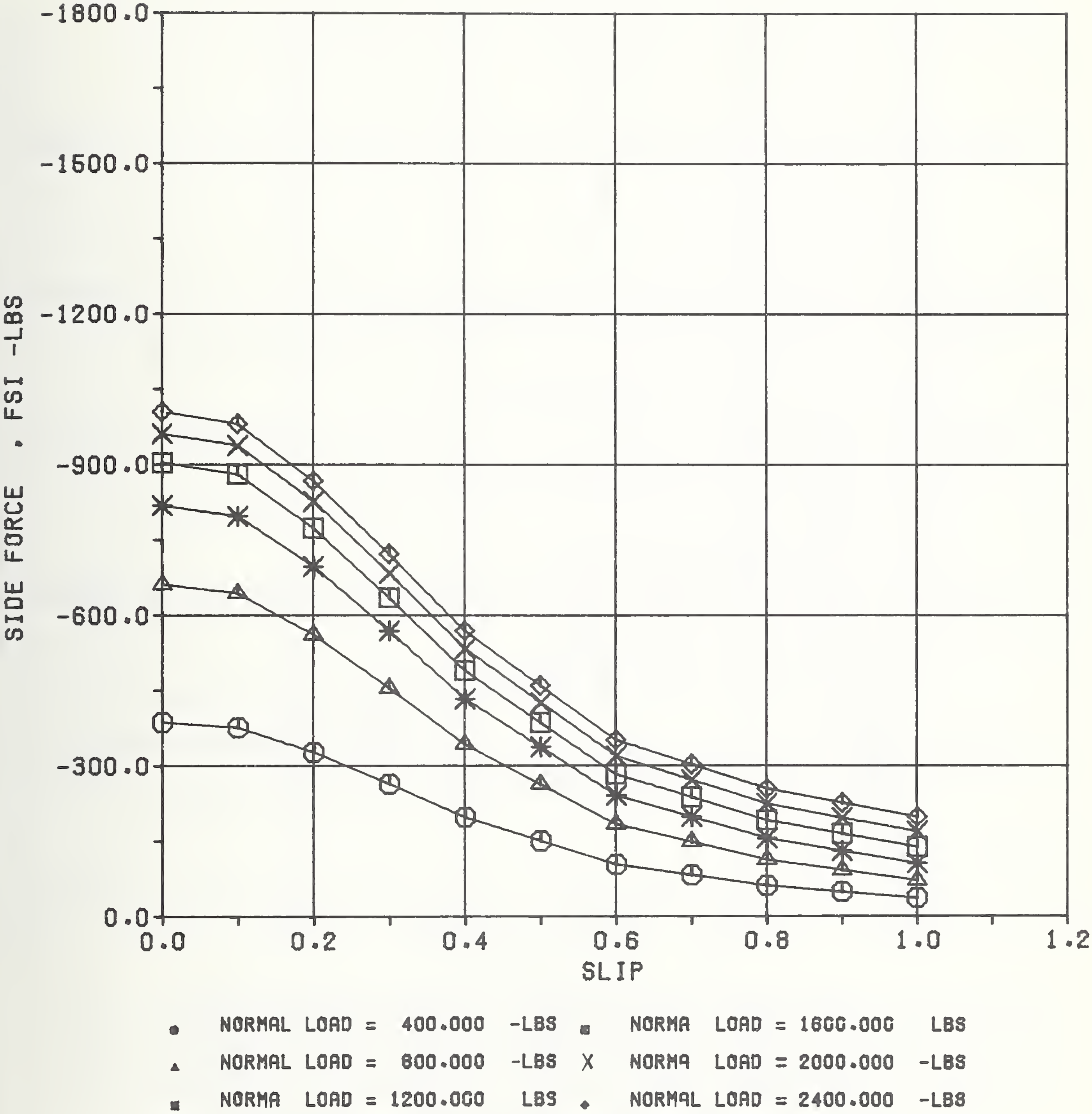


Fig. F-6 Side Force versus Slip with Normal Load Varying, 4 May 1978
(235 185-14X MI R XWW, slip angle = 8., camber = 0.)

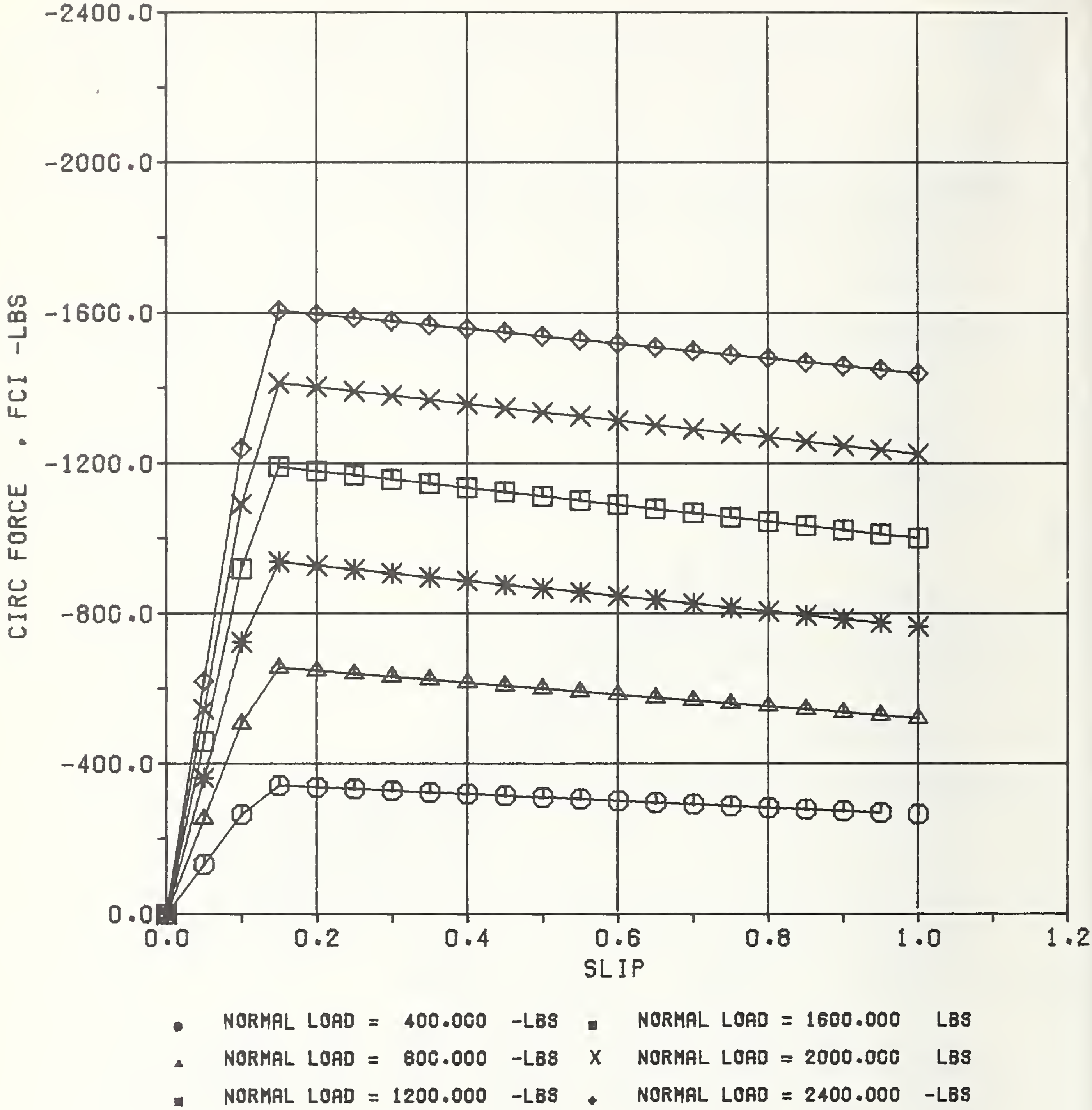


Fig. F-7 CIRC Force versus Slip with Normal Load Varying, 4 May 1978
(235 185-14X MI R XWW, slip angle = 0., camber = 0.)

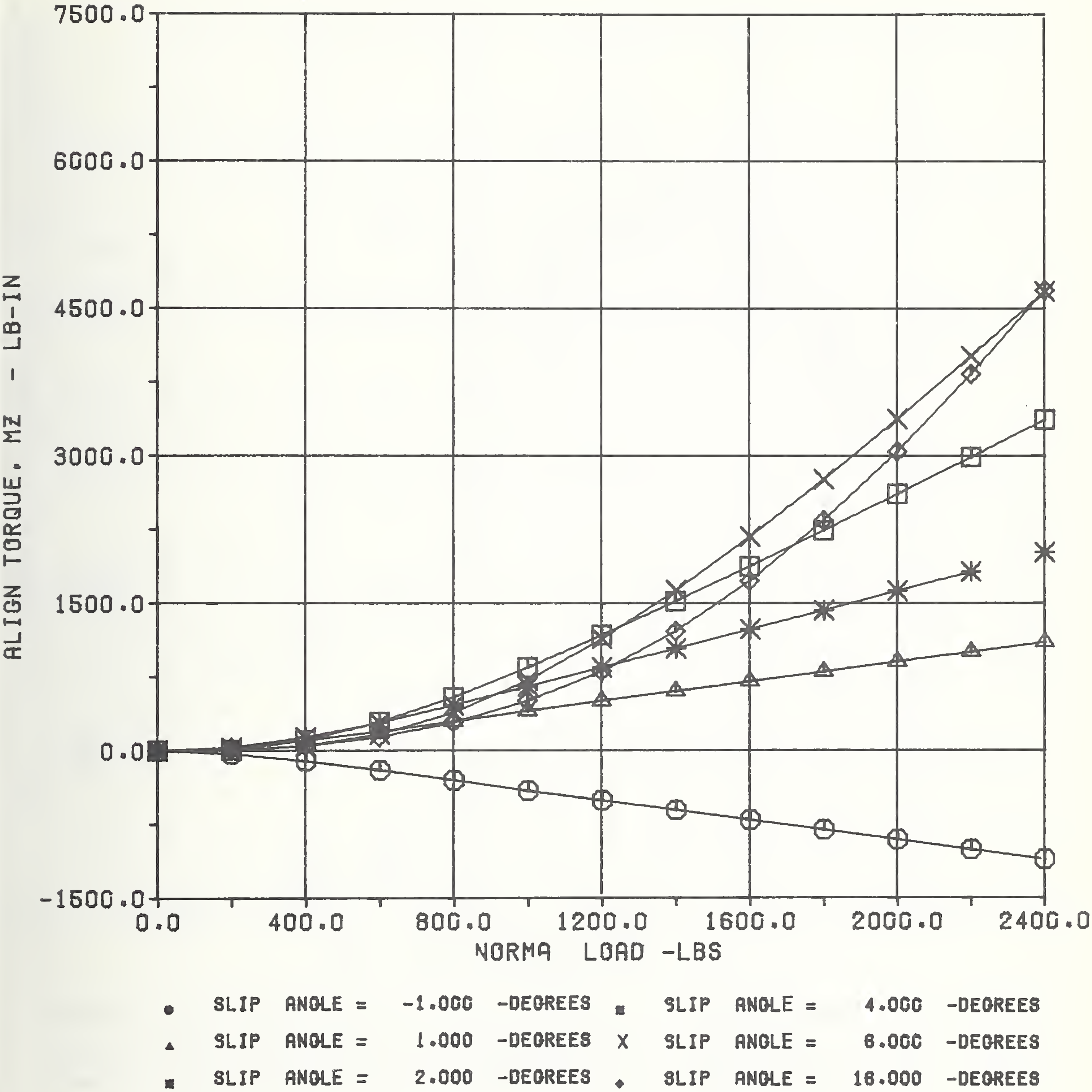


Fig. F-8 Align Torque versus Normal Load with Slip Angle Varying, 4 May 1978
(235 185-14X MI R XWW, camber angle = 0., slip = 0.)

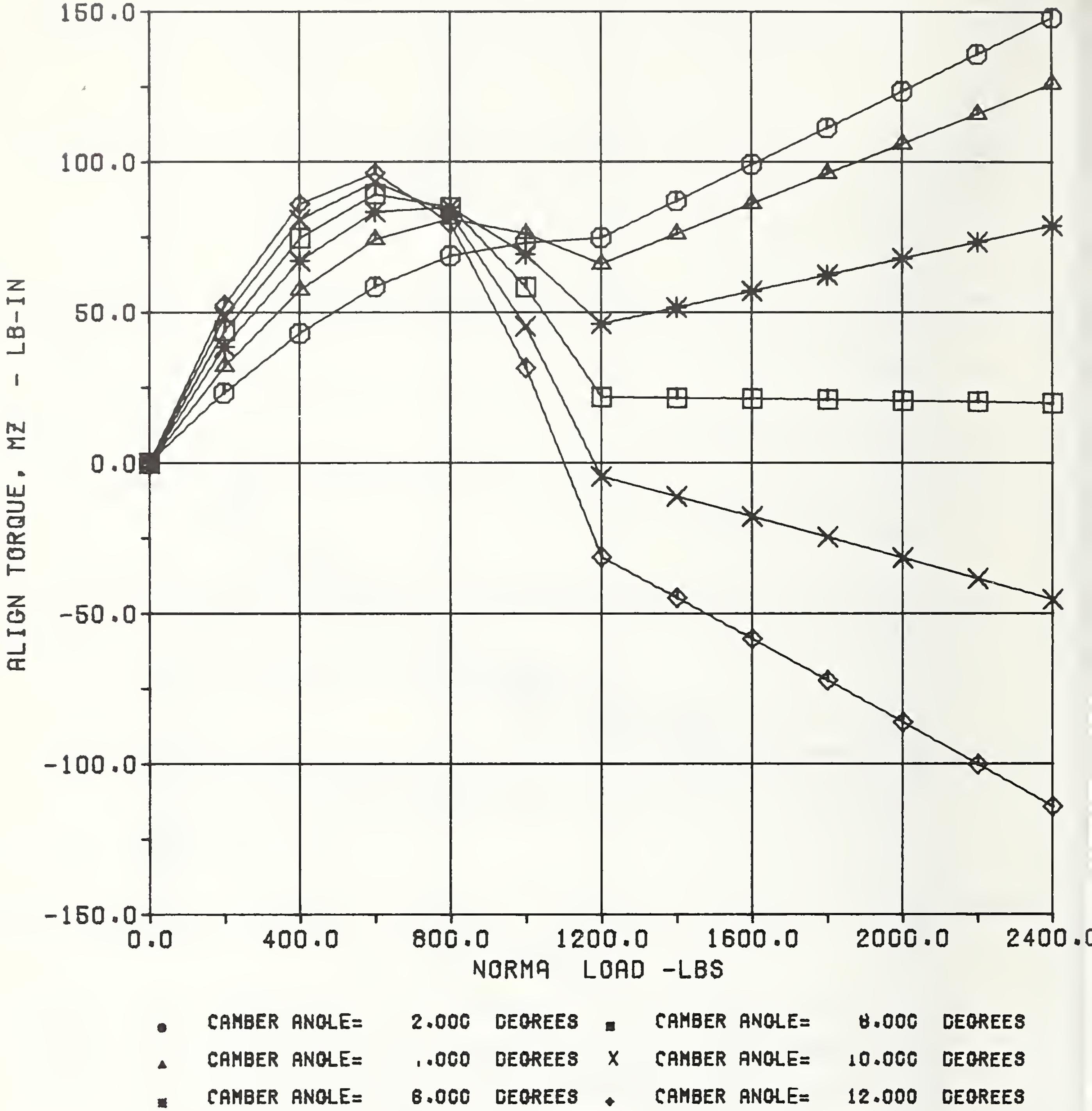


Fig. F-9 Align Torque versus Normal Load with Camber Angle Varying, 4 May 1978 (235 185-14X MI R XWW, slip angle = 0., slip = 0.)

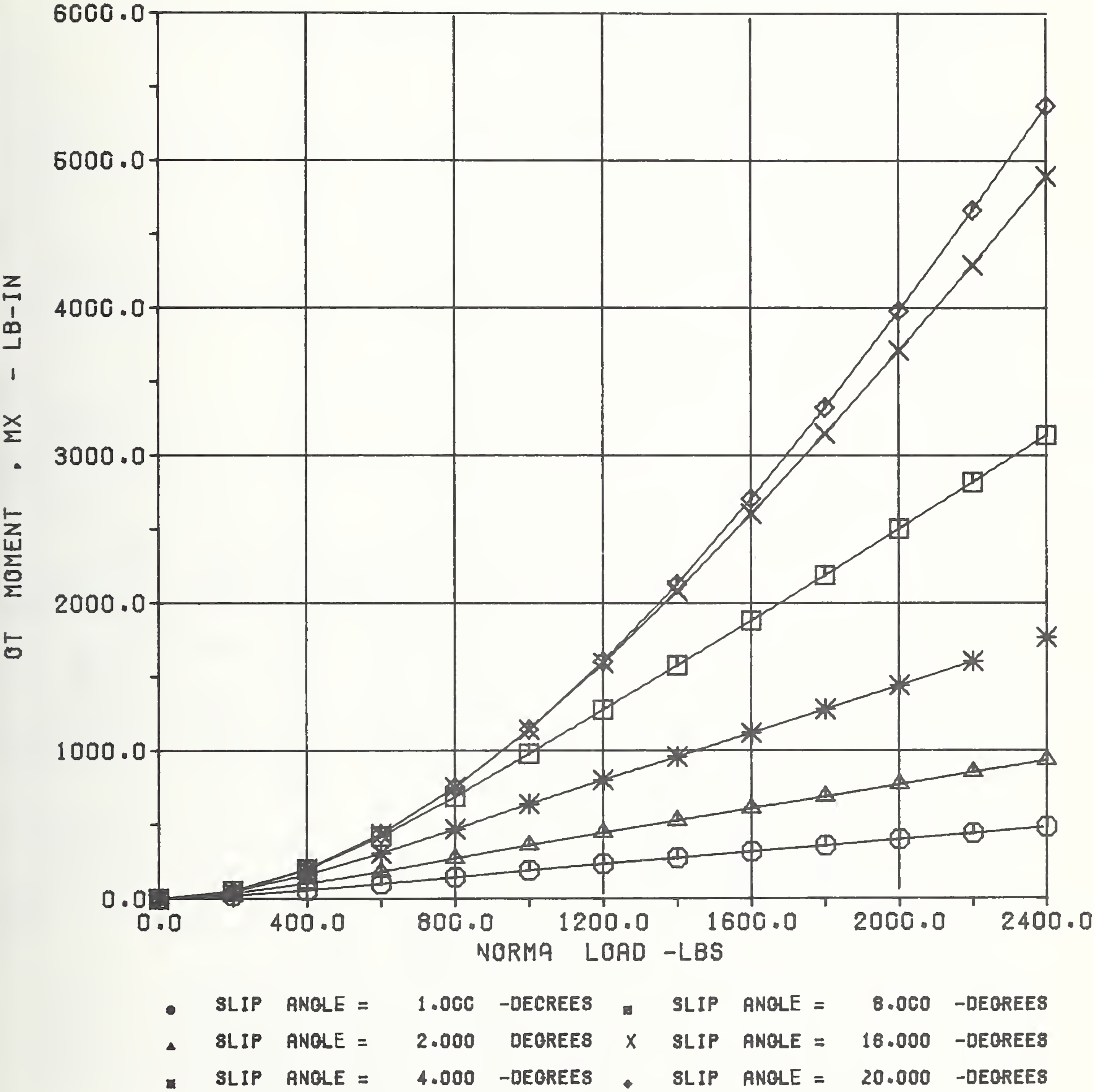


Fig. F-10 OT Moment versus Normal Load with Slip Angle Varying, 4 May 1978 (235 185-14X MI R XWW, camber = 0., slip = 0.)

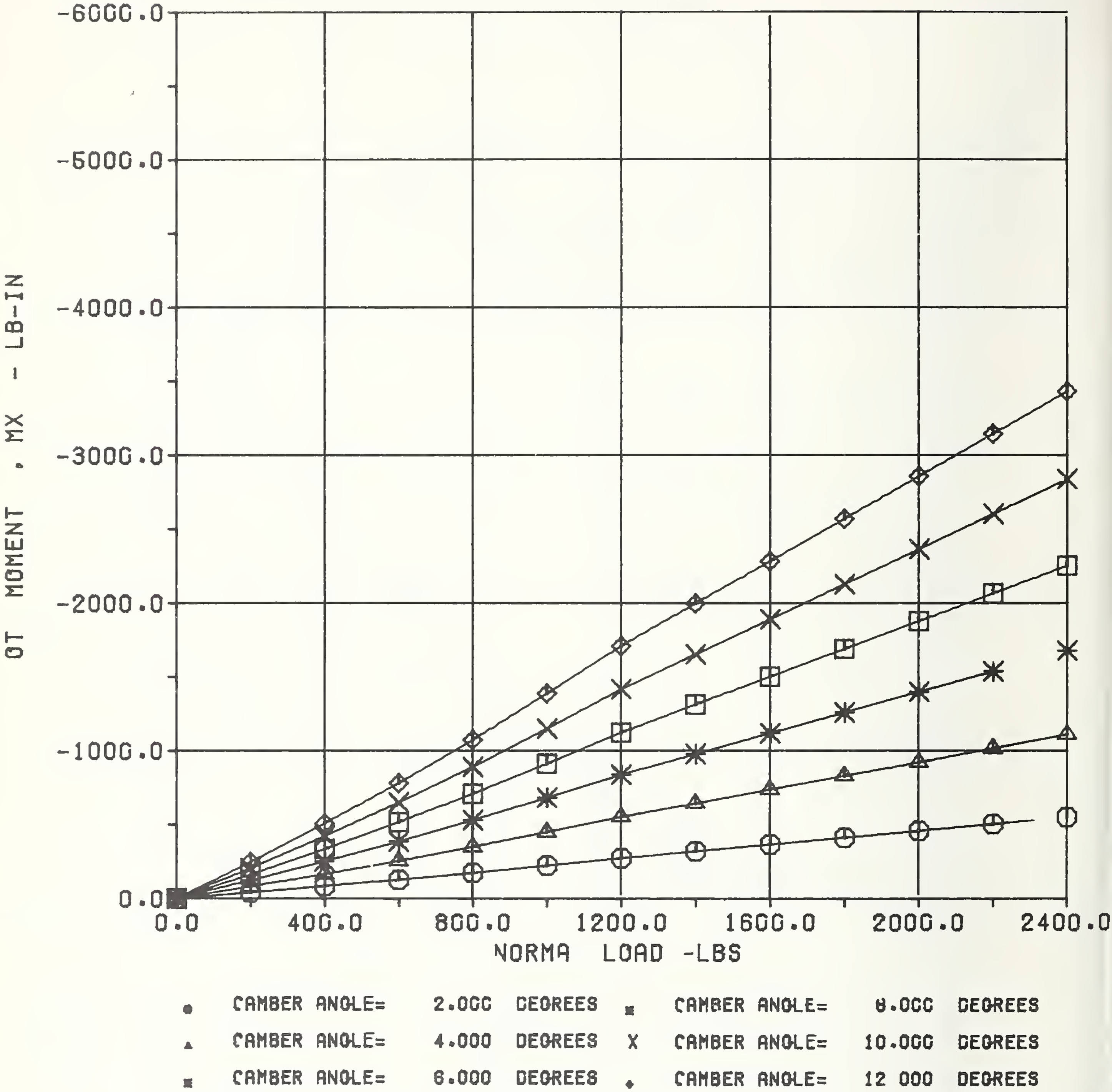


Fig. F-11 OT Moment versus Normal Load with Camber Angle Varying, 4 May 1978 (235 185-14X MI R XWW, slip angle = 0., camber = 0.)

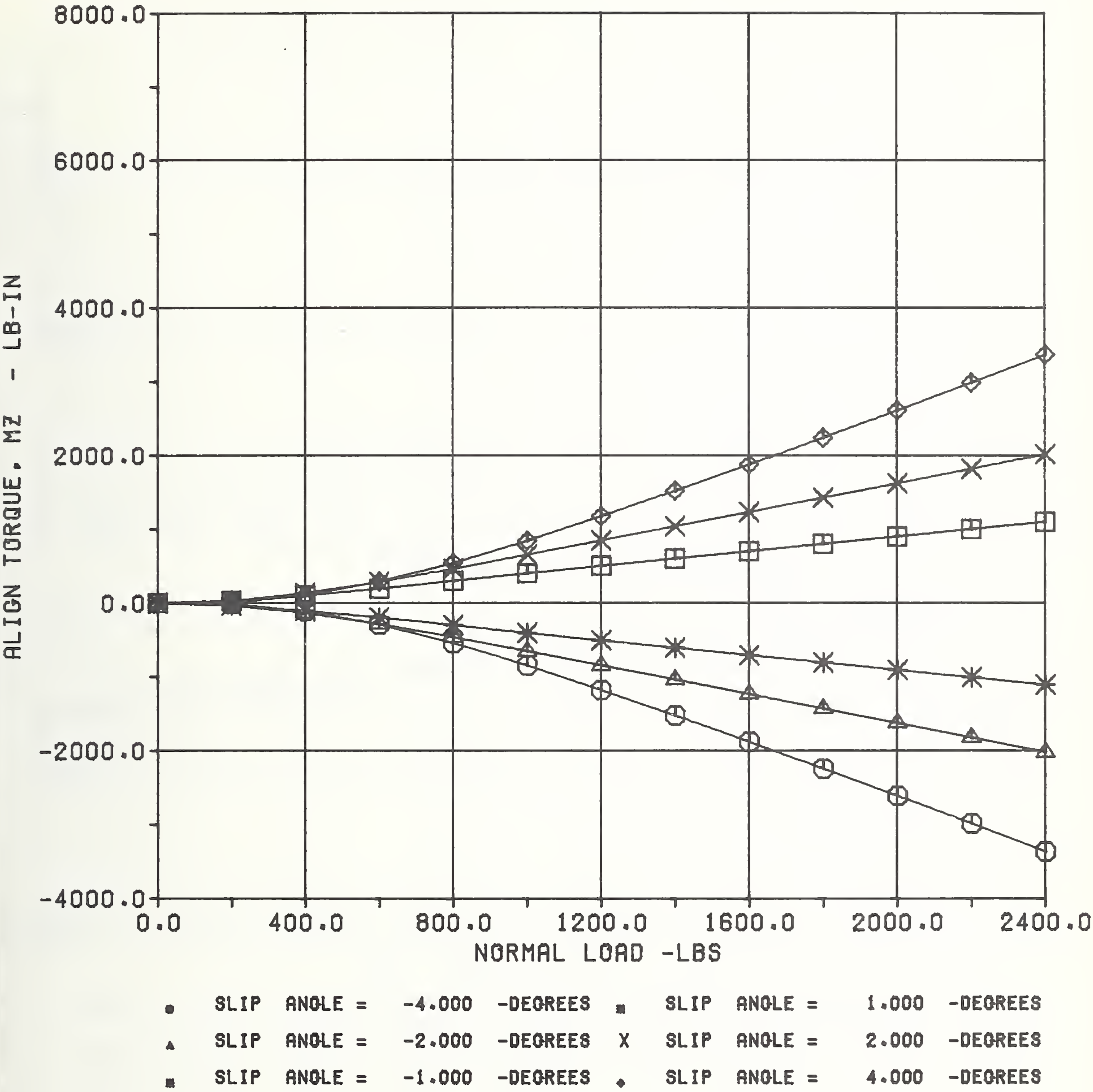


Fig. F-12 Align Torque versus Normal Load with Slip Angle Varying, 5 May 1978
(235 185-14X MI R XWW, camber = 0., slip = 0.)

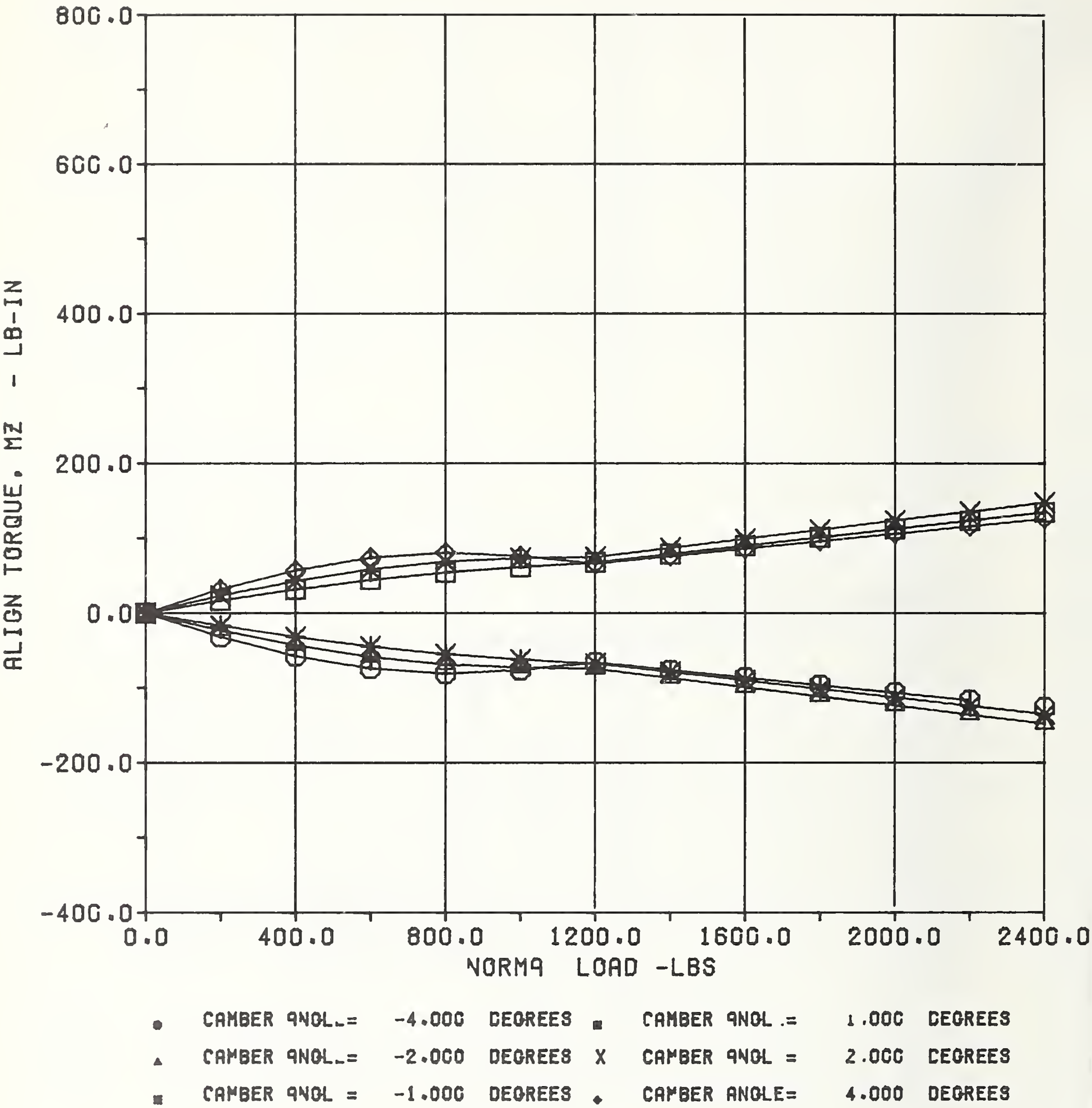


Fig. F-13 Align Torque versus Normal Load with Camber Angle Varying, 4 May 1978 (235 185-14X MI R XWW, slip angle = 0., slip = 0).

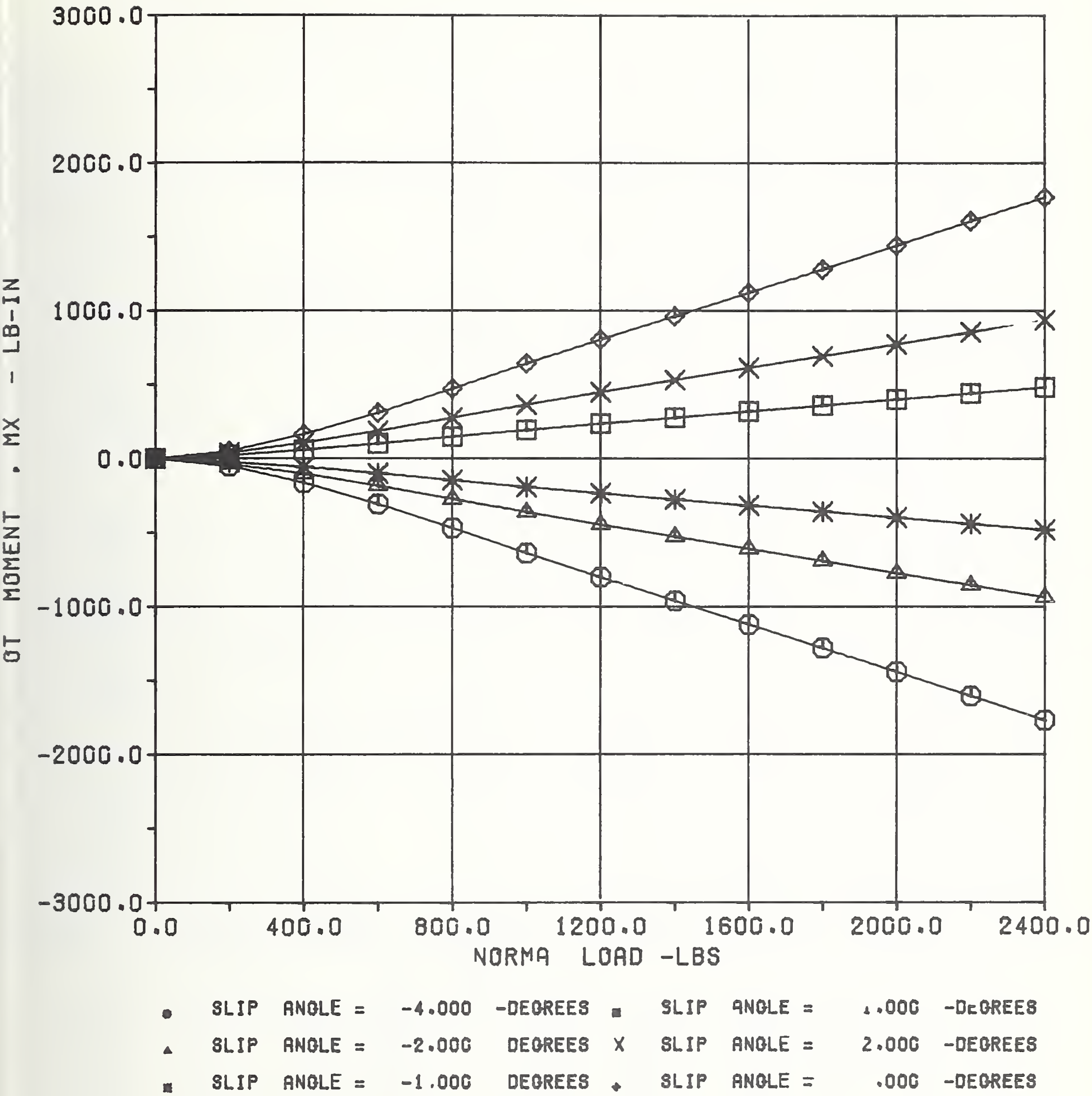


Fig. F-14 OT Moment versus Normal Load with Slip Angle Varying, 4 May 1978
(235 185-14X MI R XWW, camber = 0., slip = 0.)

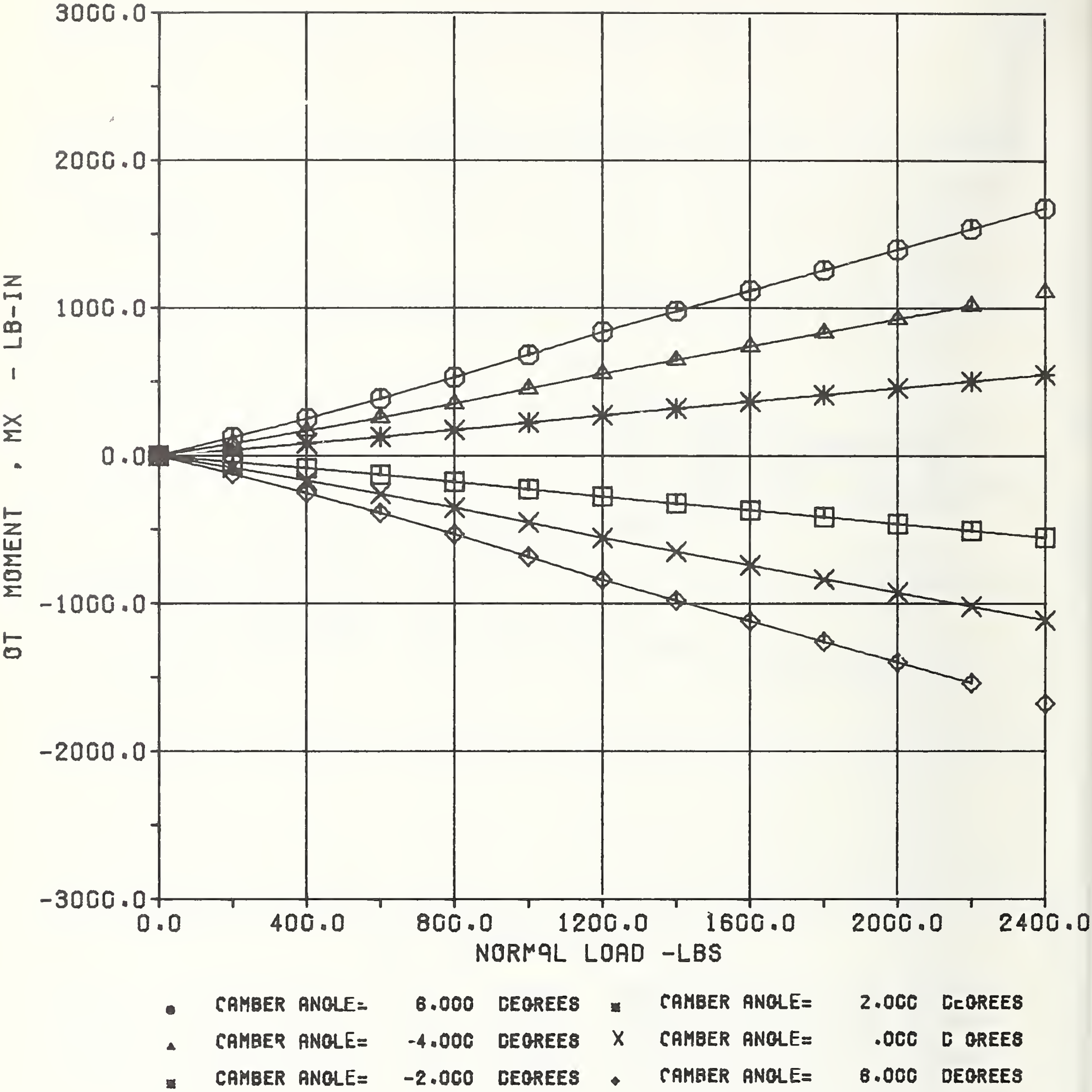


Fig. F-15 OT Moment versus Normal Load with Camber Angle Varying, 4 May 1978
(235 185-14X MI R XWW, slip angle = 0., slip = 0.)

Tire Identification

TIRF Tire Number	011
Size	F78-14
Manufacturer (distributor)	GY
Brand Name	Custom power cushion polyglas
Load Range (ply rating)	B
Maximum T&RA Load (lb)	1500
Maximum Infl Press (psi)	32
No. of Plies and Cord Material — Tread	2P + 2F
Sidewall	2P
DOT No.	MP|L7|DDA|333
Construction Type	BB
Aspect Ratio, Computed	76.8
T&RA Rim Width	5.50
Shore Hardness (std var)	59.8 ( )
Remarks	

TIRF Run Identification

Run No. (0602 series)	389	464
Road Speed (mph)	30	
Water Depth (mil)	--	
Cold Infl Press (psi)	24	
100% Design Load (lb)	1280	
Rim Width (in.)	5.50	
Groove Depth (%)	100	
Road Skid No. — Dry	85	
Wet	--	

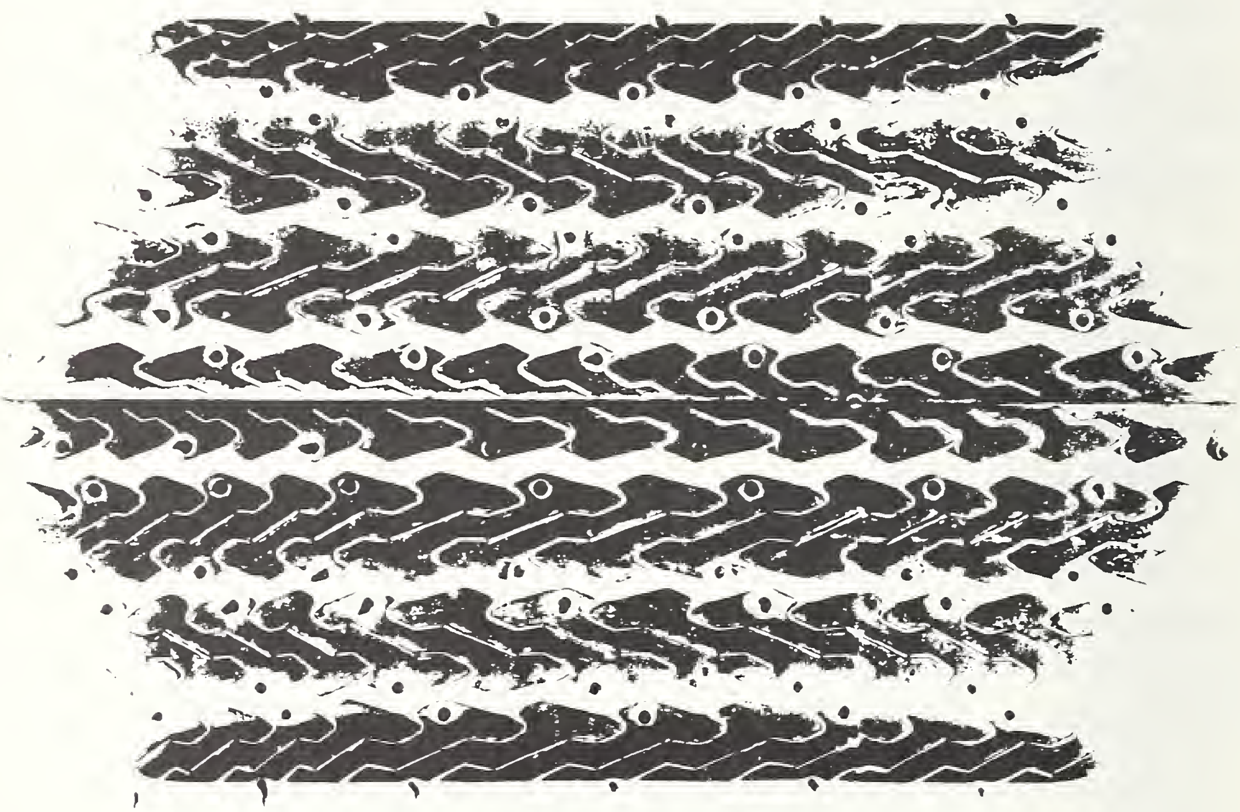
Notations

BFG	Goodrich
CO	Cooper
DA	Dayton
DU	Dunlop
FI	Firestone
GT	General Tire
GY	Goodyear
KS	Kelly Spring-field
LE	Lee
MI	Michelin
PI	Pirelli
SE	Sears
UN	Uniroyal
B	Bias ply
BB	Bias belted
R	Radial ply
F	Fiberglas
H	High performance organic fiber
N	Nylon
P	Polyester
R	Rayon
S	Steel
TT	Tube-type
TL	Tubeless

Tire Uniformity

(SAE recommended practice J332A)

TIRF Tire No.		011
Test Load at 28 psi (lb)		1090
Radial Force Variation, Peak-to-Peak (lb)	Total	22
	First harmonic	4
Lateral Force Variation, Peak-to-Peak (lb)	Total	8
	First harmonic	4
Mean Lateral Force (lb)	Forward	-40
	Reverse	+27
Conicity (lb)		-9
Ply Steer (lb)		-33



East ↓ Tire No. 011

CORNERING COEFFICIENTS

RUN: 389- 2- 6

CORNERING STIFFNESS, LB/RAD		
	A0	3318.89
	A1	7.40
	A2	2804.77
CAMBER STIFFNESS, LB/RAD		
	A3	1.266
	A4	6024.23
PEAK LATERAL FRICTION COEFFICIENT, LB/LB		
	B3	1.143
	B1	-2.848E-04
	B4	4.342E-08
OVERTURNING MOMENT, FT LB		
	C1	-1.162E-04
	C2	-5.638E-05
	C3	-0.446
ALIGNING TORQUE, FT LB		
	K1	-2.445E-04
	K2	2.343E-04
	K3	0.127

**************************** TEST DATA ****************************

LOAD LB	CALPHA LB/DEG	CA/FZ LB/DEG/LB	NALPHA FTLB/DEG	NA/FZ FTLB/DEG/LB	NA/CA FT
2234.8	119.6	0.054	51.6	0.023	0.432
1913.8	132.6	0.069	46.2	0.024	0.349
1595.0	144.2	0.090	40.0	0.025	0.277
1276.3	149.5	0.117	30.1	0.024	0.201
959.9	145.0	0.151	20.6	0.021	0.142
637.3	118.3	0.186	10.8	0.017	0.092

LOAD LB	CGAMMA LB/DEG	CG/FZ LB/DEG/LB	NGAMMA FTLB/DEG	NG/FZ FTLB/DEG/LB	NG/CG FT
2234.8	33.0	0.015	4.4	0.002	0.134
1913.8	28.1	0.015	4.0	0.002	0.142
1595.0	25.0	0.016	3.6	0.002	0.145
1276.3	22.4	0.017	3.5	0.003	0.158
959.9	20.6	0.021	3.6	0.004	0.172

LOAD LB	CG/CA	MUY PEAK	SA @ MUY PEAK DEG
2234.8	0.276	0.73	28.8
1913.8	0.212	0.74	21.5
1595.0	0.173	0.80	19.3
1276.3	0.150	0.86	18.4
959.9	0.142	0.91	17.1
637.3		0.98	-15.2

BRAKING COEFFICIENTS

RUN: 464- 2- 6

PEAK BRAKING COEFFICIENT, LB/LB

	P0	1.0635	0.8879
	P1	-2.127E-04	3.651E-05
	P2		-8.913E-08

PEAK LONGITUDINAL SLIP

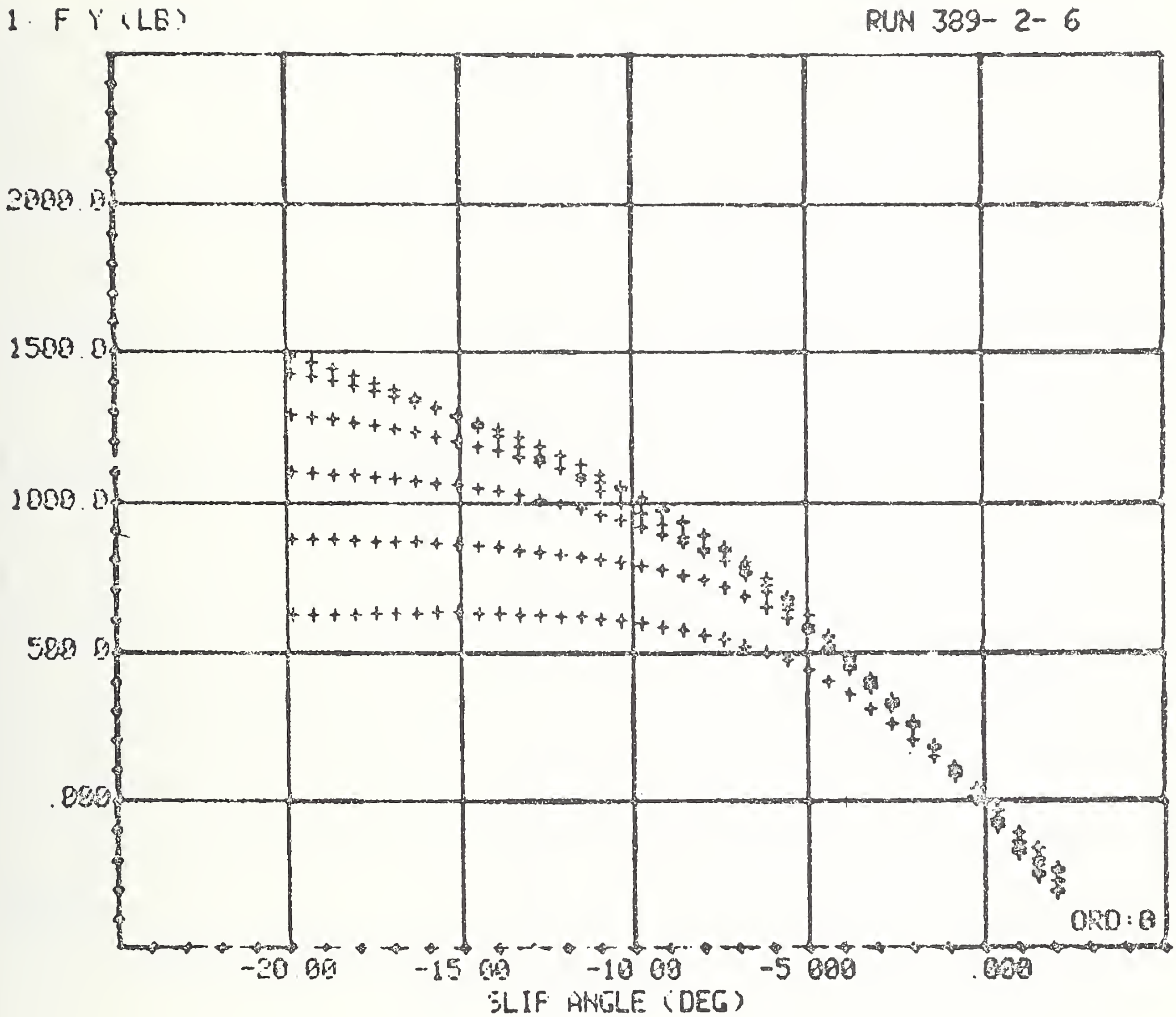
	R0	-0.180	
	R1	-2.230E-06	

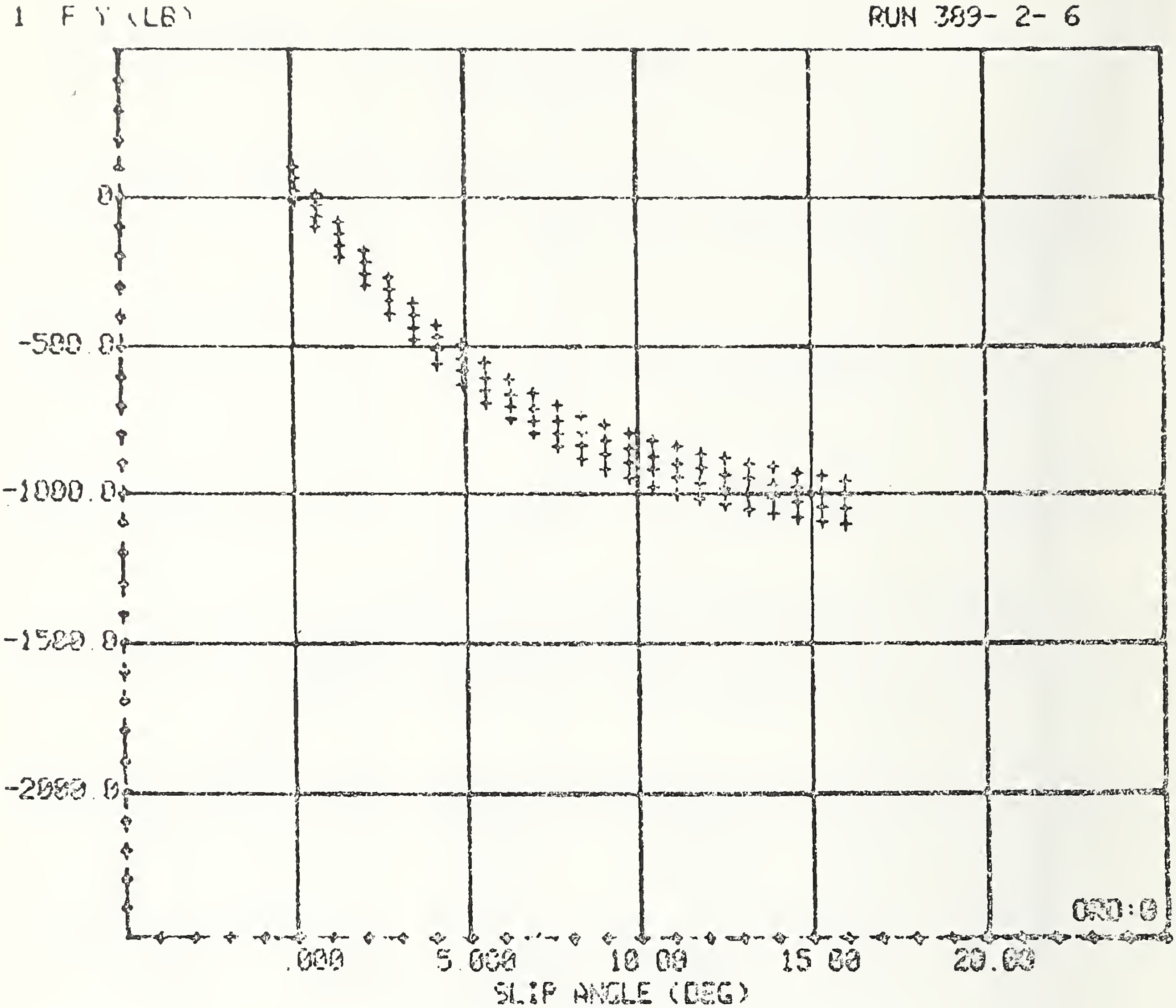
SLIDE BRAKING COEFFICIENT, LB/LB

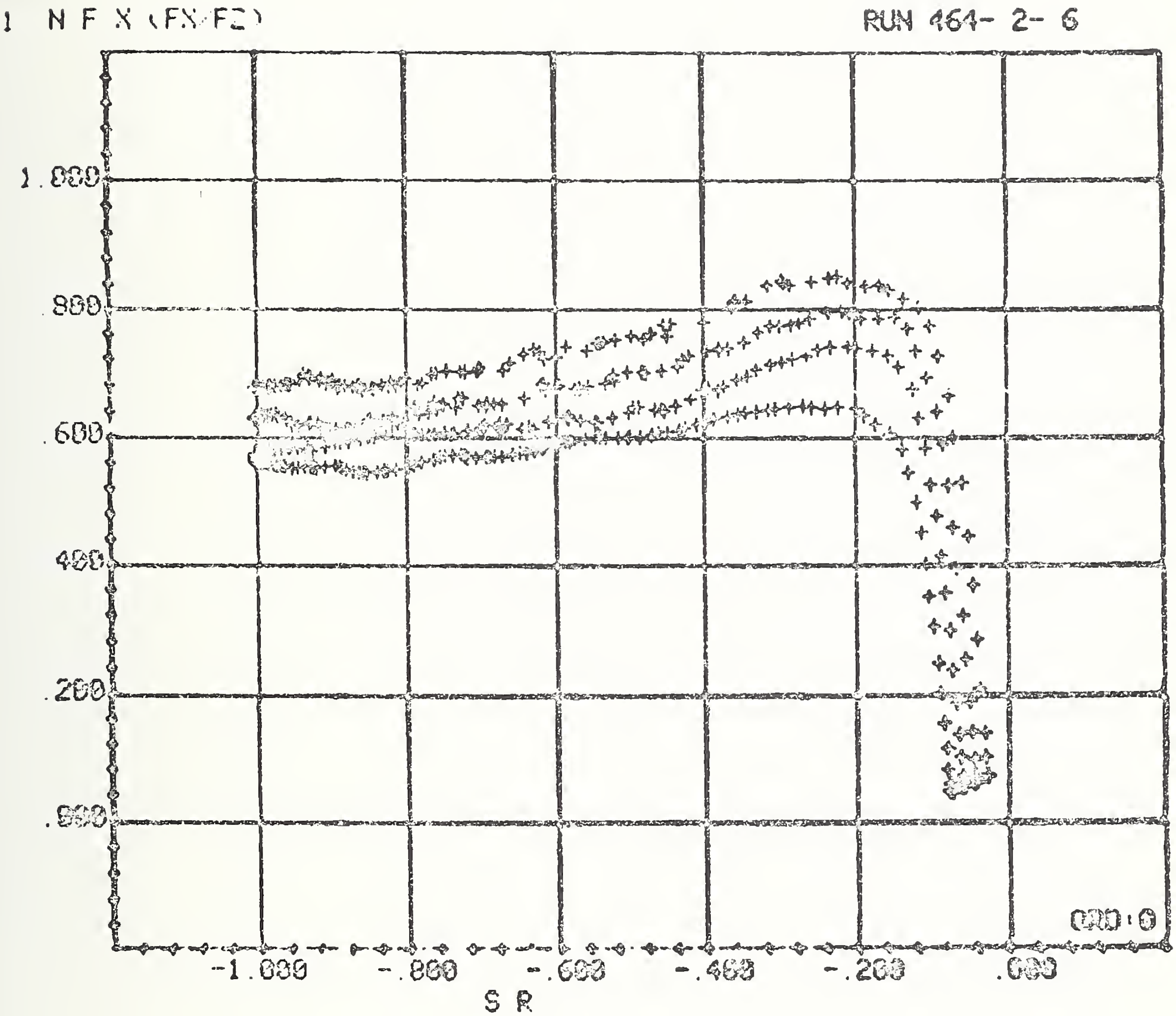
	S0	0.7873	0.9844
	S1	-1.257E-04	-4.221E-04
	S2		1.040E-07

************************** TEST DATA **************************

LOAD LB	SL PEAK	MUX PEAK	MUX SLIDE	CS LB	CS/FZ LB/LB
1906.4	-0.196	0.647	0.562	20341.1	11.55
1589.0	-0.170	0.740	0.566	24428.9	16.43
1270.4	-0.172	0.797	0.628	25350.7	20.99
954.3	-0.193	0.853	0.674	17271.0	18.80


1 F Y (LB)
RUN 389- 2- 6
2000.0
1500.0
1000.0
500.0
.000
ORD:0
-20.00
-15.00
-10.00
-5.000
.000
SLIP ANGLE (DEG)


1 F Y (LB)
RUN 389- 2- 6
0
-500.0
-1000.0
-1500.0
-2000.0
ORD:0
.000
5.000
10.00
15.00
20.00
SLIP ANGLE (DEG)


1 N F X (FX/FZ)
RUN 464- 2- 6
1.000
.800
.600
.400
.200
.000
000:0
-1.000
-.800
-.600
-.400
-.200
.000
S R

Appendix G

SIMULATION DATA

G-1. Input Data Decks

This section presents the listing of three input data decks:

1. Four-wheeled independent suspension, Volkswagen Campmobile;

2. Independent front, solid rear suspension, Dodge Coronet; and

3. Solid front and rear suspensions with dual rear tires, Winnebago Motor Home.

G-1.1. Four-Wheeled Independent Suspension, Volkswagen Campmobile

```
091 CARSSS  VW VAN
DELFW1 DELFW2
TAUC
CXC CYC CZC CLC CMC CNC
SFXS SFYS SFZS
SNPHIS SNTHES SNPSIS
SFXU SFYU
SNPHIU SNTHEU SNPSIU
PHIDT THEDT PSIDT
PHI THE PSI
PDT QDT RDT
P Q R
UDT VDT WDT
U V W

PFL AXAVE TIMDEC AYMAX SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)
 PFL AXAVE AYMAX BETDMX CUVRAT SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)      MAIN  50
      BMPN BMPS AYMAX RMAX CUVRAT BETDMX                                 MAIN  60
STR4 BETAMX BETDMX CUVRAT AYMAX RMAX PHIMAX
 STR5 AYMAX DEL BETAMX DELPSI PHIMAX UIN
PHIMAX PHIDMX RMAX ZIMX(1) ZIMX(2) ZIMX(3) ZIMX(4) UIN  HRKOFF           MAIN  90
 PFL AXAVE AYMAX BETDMX CUVRAT SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)      MAIN 100
IOUT(01) 50.
IOUT(02) 100.
IOUT(03) 50.
IOUT(04) 625.
      IOUT(05) .04
IOUT(06) 0.4
IOUT(07) 2.0
IOUT(08) 1.0
      IOUT(09) .8
IOUT(10) .003
IOUT(11) 0.25
IOUT(12) 0.25
IOUT(13) 1.25
IOUT(14) 0.1
      IOUT(15) .2
IOUT(16) 1.25
      IOUT(17) .01
IOUT(18) 1.25
      NOTUSED(1) 1.
      NOTUSED(1) 1.
      IOUT(21) -1000.
      IOUT(22) -1000.
      IOUT(23) -1000.
      IOUT(24) -1000.
      IOUT(25) 10000.
      IOUT(26) 10.
      IOUT(27) 400.
IOUT(28) 1000.
IOUT(29) -1000.
IOUT(30) 28.
      IOUT(31) 10.
      IOUT(32) 10.
IOUT(33) 20000.
IOUT(34) 20000.
IOUT(35) 20000.
IOUT(36) 20000.
ETAX 1.4
```

```
      IOUT(38) 10000.
      IOUT(39) 10000.
      IOUT(40) 10000.
      IOUT(41) 10000.
      IOUT(42) 10000.
      IOUT(43) 10.
      IOUT(44) 10000.
      IOUT(45) 10.
      IOUT(46) 10000.
ETAL 1.4
BTV 1.5706
ENDNODAC                                                            MAIN 590
U 1200.
V 1000.
W 100.
PHI -.66667
PSI 4.
THE 0.25
P 2.0
Q 0.8
DEL1DT -100.
DEL2 10.
DEL2DT -100.
DEL1 10.
DEL3DT -100.
DEL3 10.
DEL4DT -100.
DEL4 10.
UDT -800.
VDT -1500.
R 4.
DELFW1 -0.5
DELFW2 -0.5
RDT -20.
      ARPS(1) -100.
      ARPS(2) -100.
      ARPS(3) -100.
      ARPS(4) -100.
S1P 2000.
S2P 2000.
ZETDRF 100.
ZETDLF 100.
ZETDRR 100.
ZETDLR 100.
QDT -2.
PDT -12.
WDT 200.
PHIDT -2.
THEDT -.25
PSIDT -2.
ENDNOADC                                                            MAIN 880
ALAMDA=0.
PARAM(341) 0.0
PARAM(342) 0.0
PARAM(343) 0.0
PARAM(344) 0.0
                                                                    MAIN 890
INDXCN 1
                                                                    MAIN 900
VEHICLE MODEL * VW CAMPMOBILE 1973
```

```
0.9509401 .06331873 .04225659 .04367653 .01231053 .0010975920.0
2.757724  -.1297874 -.03045931-.00649462-.00049561.0000235900.0
-.07321143-.03634039-.01556503-.00756957-.00160251-.000129640.0
-1.010893 .7207570  -.00401940.004555903-.00042666-.000099750.0
0.0       0.0       0.0       0.0       0.0       0.0       0.0
-.05058013-.06585461-.02369034-.00156075.000995467.0002581200.0
0.0       0.0             TABLE I * BRAKE TORQUE FUNCTION
1000.     8900.
99999.                                                                    MAIN1020
0.0       0.0             TABLE II * BRAKE TORQUE FUNCTION
1000.     8900.
99999.                                                                    MAIN1070
0.0        0.00     TABLE III- SIDE FORCE SHAPING FUNCTION
0.05       .01
0.1        .03
0.15       .07
0.2        .17
0.30       .35
0.4        .54
0.6        .81
0.8        .93
1.0        1.
99999.                                                                    MAIN1180
-1000.    528.          WIND PROFILE
0.        528.
1000.     528.
99999.
-3.14159  0.535     0.01      -0.025    0.086     -0.117    -0.003
-2.87979  0.805     0.85      -0.435    0.433     -0.169    -0.188
-2.61799  0.920     1.56      -0.750    0.674     -0.259    -0.280
-2.35619  0.810     2.12      -1.030    0.828     -0.332    -0.391
-2.09440  0.585     2.16      -1.275    0.876     -0.300    -0.291
-1.83260  0.330     2.55      -0.260    1.115     -0.139    -0.212
-1.57080  0.105     2.78      -0.170    1.117     0.062     -0.066
-1.3090   -0.074    2.74      -0.432    1.085     0.030     0.117
-1.0472   -0.297    2.63      -1.195    0.887     0.237     0.250
-.78540   -0.472    2.33      -1.280    0.848     0.252     0.417
-.69813   -0.562    2.07      -1.070    0.800     0.243     0.420
-.61087   -0.630    1.84      -0.910    0.723     0.232     0.416
-.52360   -0.680    1.61      -0.773    0.651     0.221     0.402
-.43633   -0.708    1.37      -0.660    0.562     0.212     0.376
-.34907   -0.715    1.14      -0.550    0.478     0.197     0.337
-.26180   -0.690    0.87      -0.445    0.363     0.172     0.272
-.17453   -0.640    0.60      -0.333    0.252     0.139     0.171
-.08727   -0.600    0.33      -0.276    0.138     0.125     0.080
0.0       -0.578    0.0       -0.252    0.011     0.121     -0.003
 0.08727  -0.590    -0.32     -0.280    -0.089    0.136     -0.082
 0.17453  -0.630    -0.62     -0.355    -0.203    0.153     -0.168
 0.26180  -0.680    -0.89     -0.465    -0.316    0.187     -0.257
 0.34907  -0.702    -1.13     -0.593    -0.423    0.227     -0.332
 0.43633  -0.710    -1.35     -0.615    -0.511    0.255     -0.380
 0.52360  -0.690    -1.65     -0.860    -0.619    0.266     -0.407
 0.61087  -0.615    -1.90     -1.012    -0.716    0.259     -0.434
 0.69813  -0.560    -2.17     -1.150    -0.790    0.262     -0.439
 0.78540  -0.472    -2.33     -1.280    -0.848    0.262     -0.417
 1.04720  -0.297    -2.63     -1.195    -0.887    0.237     -0.250
 1.30900  -0.074    -2.74     -0.432    -1.085    0.030     -0.117
 1.57080  0.105     -2.78     -0.170    -1.117    0.062     0.066
 1.83260  0.330     -2.55     -0.260    -1.115    -0.139    0.212
 2.09440  0.585     -2.16     -1.275    -0.876    -0.300    0.291
```

```
 2.35619  0.810     -2.12     -1.030    -0.828    -0.332    0.309
 2.61799  0.920     -1.56     -0.750    -0.674    -0.259    0.280
 2.87979  0.805     -0.85     -0.435    -0.443    -0.169    0.188       MICROBUS
 3.14159  0.535     -0.01     -0.025    -0.086    -0.117    0.003       AERO DATA
99999.
0.0       0.0
99999.
0.0       0.0           STEER PROFILE
0.25      -13.6
1.25      -31.45
1.55      135.
1.75      125.46
2.0       62.73
2.3       -200.
2.5       -204.
6.        -204.
99999.
-10.0      -20688.73    VW FRONT SPRING DATA
-5.67      -1580.44     VW FRONT
-4.92      -908.44      VW FRONT
-3.74      -482.46      VW FRONT
0.         0.
.43        55.47        VW FRONT
10.        9003.42      VW FRONT
99999.
-10.0      -20688.73    VW FRONT SPRING DATA
-5.67      -1580.44     VW FRONT
-4.92      -908.44      VW FRONT
-3.74      -482.46      VW FRONT
0.         0.
.43        55.47        VW FRONT
10.        9003.42      VW FRONT
99999.
-10.       -16375.09    VW REAR SPRING DATA
-4.61      -1466.35     VW REAR
-3.54      -980.57      VW REAR
-1.57      -334.41      VW REAR
0.         0.           VW REAR
2.28       485.64       VW REAR
10.        8136.16      VW REAR
99999.
-10.       -16375.09    VW REAR SPRING DATA
-4.61      -1466.35     VW REAR
-3.54      -980.57      VW REAR
-1.57      -334.41      VW REAR
0.         0.           VW REAR
2.28       485.64       VW REAR
10.        8136.16      VW REAR
99999.
-100      -466.               FRONT SHOCK ABSORBER DATA MICROBUS
-26.7     -150.
-13.25    -92.
-4.71     -27.
0.0       0.0
4.71      130.
13.25     390.
26.7      585.
100.      1648.
99999.
-100      -466.               FRONT SHOCK ABSORBER DATA
```

```
-26.7      -150.
-13.25     -92.
-4.71      -27.
0.0        0.0
4.71       130.
13.25      390.
26.7       585.
100.       1648.
99999.
-100.      -425.                    REAR SHOCK ABSORBER DATA
-26.7      -125.
-13.25     -70.
-4.71      -30.
0.0        0.0
4.71       50.
13.25      175.
26.7       315.
100.       1078.
99999.
-100.      -425.                    REAR SHOCK ABSORBER DATA
-26.7      -125.
-13.25     -70.
-4.71      -30.
0.0        0.0
4.71       50.
13.25      175.
26.7       315.
100.       1078.
99999.
066  40.        40.       40.       30.       40.       45.       50.
074  0.         0.        0.        30.       0.        0.        0.
076  5.         10.       10.       5.        5.5       4.        3.
114  62.        0.        39.       72.       0.        0.        0.
115  1.         0.        1.        1.        1.        0.        0.
116  .5         100.      .5        .5        .4        100.      100.
117  3.         0.        3.        0.        0.        0.        0.
118  3.         0.        3.        0.        0.        0.        0.
121  300.       200.      200.      0.        0.        0.        1500.
124  0.         0.        0.        0.        0.        2.        1.
125  0.         0.        0.        0.        0.        0.        1.
126  0.         0.        0.        0.        0.        1.        1.
128  3.         1.        3.        4.        2.        5.        6.
192  1.         .1        .1        .1        .1        .1        .05
198  0.         0.        0.        12.       0.        0.        0.
199  0.         0.        0.        57.6      0.        0.        0.
201  0.         0.        0.        1000.     0.        0.        0.
277  0.         0.        0.        8.        0.        0.        0.
278  0.         0.        0.        0.        0.        0.        .52
279  0.         0.        0.        0.        0.        0.        1.02
123  0.         0.        0.        0.        0.        0.        0.
123  0.         0.        0.        0.        0.        0.        0.
123  0.         0.        0.        0.        0.        0.        0.
123  0.         0.        0.        0.        0.        0.        0.
123  0.         0.        0.        0.        0.        0.        0.
123  0.         0.        0.        0.        0.        0.        0.
123  0.         0.        0.        0.        0.        0.        0.
001 8.6
002 .507
003 .489
004 19.98
```

```
005 19.92
006 49.65
007 44.85
008 54.8
009 57.2
010 0.
011 7380.
012 24980.
013 25660.
014 1140.
015 696969.
016 30.
017 153000.
018 10.
019 129.
020 129.
021 213.
022 213.                                                    MAIN1820
023  0.
024 0.
025 33.
026 33.
027 56.
028 56.
029 0.0
030 0.
031 12.75
032 2000.
033 .5
034 4566.64
035 7.87
036 2303.58
037 0.294
038 -1747.37
039 0.
040 0.
041 8592.
042 16.3
043
044
045
046
047 8.27
048 696969.
049 8.93
050 9.28
051 .3
052 5.375
053 0.
054 0.
055 .59
056 3.47
057 -3.47
058 -.0873
059 .0873                                                   MAIN2190
060  1.0
061 0.0
062 0.0                                                     MAIN2220
063                                                         MAIN2230
064
```

```
                                                        MAIN2240
065                                                     MAIN2250
066  40.                                                MAIN2260
067                                                     MAIN2270
068                                                     MAIN2280
069                                                     MAIN2290
070                                                     MAIN2300
071                                                     MAIN2310
072                                                     MAIN2320
073                                                     MAIN2330
074
075 .005                                                MAIN2350
 76  5.0
077 894.
078 894.
079 894.
080 894.                                                MAIN2400
081                                                     MAIN2410
082                                                     MAIN2420
083                                                     MAIN2430
084
085 -.0002056
086 0.0
087 1.045
088 .00000003991                                        MAIN2480
089                                                     MAIN2490
090                                                     MAIN2500
091   0.0
092 -1.54
093 -1.03                                               MAIN2530
094                                                     MAIN2540
095                                                     MAIN2550
096                                                     MAIN2560
097                                                     MAIN2570
098                                                     MAIN2580
099                                                     MAIN2590
100                                                     MAIN2600
101                                                     MAIN2610
102                                                     MAIN2620
103                                                     MAIN2630
104                                                     MAIN2640
105                                                     MAIN2650
106                                                     MAIN2660
107   1.0                                               MAIN2670
108 .4
109 0.0
110 4428.
111 738.                                                MAIN2710
112  0.0                                                MAIN2720
113  1.                                                 MAIN2730
114  62.                                                MAIN2740
115  1.0                                                MAIN2750
116  0.5                                                MAIN2760
117  3.                                                 MAIN2770
118  3.
119 0.0
120 0.0                                                 MAIN2800
121  300.                                               MAIN2810
122                                                     MAIN2820
123                                                     MAIN2830
124
```

```
125                                MAIN2840
126                                MAIN2850
127                                MAIN2860
128  3.0                           MAIN2870
129 0.                             MAIN2880
130 .038
131 .320
132 44000.
133 44000.
134 6.2
135 6.20
136 17.6
137 126.
138 5.68
139 .010
140 -.010
141 0.
142 0.0                            MAIN3010
143 0.
144 0.
145 .0000001147
146 0.0
147 0.0
148 0.0
149 0.0
150 0.0
151 0.0
152 0.0
153 0.0
154 0.0
155 0.0
156 4233.6
157 94.5
158 1094.0
159                                MAIN3180
160                                MAIN3190
161                                MAIN3200
162                                MAIN3210
163                                MAIN3220
164                                MAIN3230
165                                MAIN3240
166                                MAIN3250
167                                MAIN3260
168                                MAIN3270
169 73.
170 75.
171 75.                            MAIN3300
172 2.                             MAIN3310
173                                MAIN3320
174                                MAIN3330
175 .25
176 1.0
177                                MAIN3360
178                                MAIN3370
179
180 0.0
181
182 .13
183 .13
184 .13
```

```
.13
27.6
27.6
10.6
10.6
1.
0.0
0.
0.
1.5
0.8988
-.00009497
0.8988
-.00009497
.6770
.6770
.03
0.
-.00003226
-.00003226
0.
0.
0.
0.0
0.0
0.0
0.
0.
0.
0.0
0.0
0.
0.
0.
0.
0.
0.
0.
0.
400.
400.
1.0
1.9
1.9
1.0
1.0
-.0000372
-.000022
.0000020
```

```
245 -.0002056
246 0.0
247 1.045
248 .00000003991
249 -.0031764
250 .0029568
251 .66
252 -.0031764
253 .0029568
254 .66
255 0.0
256 -.001302
257 -.0027288
258 -5.796
259 0.0
260 -.001302
261 -.0027288
262 -5.796
263 0.
264 0.
265 0.
266 .29
267 .03
268 0.
269 0.
270 0.
271 0.
272 .13
273 .03
274 0.                                                        MAIN4340
275  0.0                                                      MAIN4350
276  0.0                                                      MAIN4360
277  0.                                                       MAIN4370
278  0.                                                       MAIN4380
279  0.                                                       MAIN4390
280  0.
281
282                                                           MAIN4420
283  0.
284 0.0
285 3.56                                                      MAIN4450
286  0.0
287 2.                                                        MAIN4470
288  0.                                                       MAIN4480
289  4.
290 .5
291 4566.64
292 7.87
293 2303.58
294 0.294
295 -1747.37
075 .01
112 50.
175 .9985
193 0.0
194 100.
195 1200.
215 100.
216 100.
217 1.
```

```
304                                                                              MAIN4550
./        ENDUP                                                                  MAIN4560
```

G-1.2. Independent Front, Solid Rear Suspensions, Dodge Coronet

```
091 CARCAL  DODGE71
DELFW1 DELFW2
TAUC
CXC CYC CZC CLC CMC CNC
SFXS SFYS SFZS
SNPHIS SNTHES SNPSIS
SFXU SFYU
SNPHIU SNTHEU SNPSIU
PHIDT THEDT PSIDT
PHI THE PSI
PDT QDT RDT
P Q R
UDT VDT WDT
U V W

PFL AXAVE TIMDEC AYMAX SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)
 PFL AXAVE AYMAX BETDMX CUVRAT SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)      MAIN  50
      BMPN BMPS AYMAX RMAX CUVRAT BETDMX                                MAIN  60
STR4 BETAMX BETDMX CUVRAT AYMAX RMAX PHIMAX
 STR5 AYMAX DEL BETAMX DELPSI PHIMAX UIN
PHIMAX PHIDMX RMAX ZIMX(1) ZIMX(2) ZIMX(3) ZIMX(4) UIN  BRKOFF           MAIN  90
 PFL AXAVE AYMAX BETDMX CUVRAT SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)      MAIN 100
IOUT(01) 50.
IOUT(02) 100.
IOUT(03) 50.
IOUT(04) 625.
      IOUT(05) .04
IOUT(06) 0.4
IOUT(07) 2.0
IOUT(08) 1.0
      IOUT(09) .8
IOUT(10) .003
IOUT(11) 0.25
IOUT(12) 0.25
IOUT(13) 1.25
IOUT(14) 0.1
      IOUT(15) .2
IOUT(16) 1.25
      IOUT(17) .01
IOUT(18) 1.25
      NOTUSED(1) 1.
      NOTUSED(1) 1.
      IOUT(21) -1000.
      IOUT(22) -1000.
      IOUT(23) -1000.
      IOUT(24) -1000.
      IOUT(25) 10000.
      IOUT(26) 10.
      IOUT(27) 400.
IOUT(28) 1000.
IOUT(29) -1000.
IOUT(30) 28.
      IOUT(31) 10.
      IOUT(32) 10.
IOUT(33) 20000.
IOUT(34) 20000.
IOUT(35) 20000.
IOUT(36) 20000.
ETAX 1.4
```

```
      IOUT(38) 10000.
      IOUT(39) 10000.
      IOUT(40) 10000.
      IOUT(41) 10000.
      IOUT(42) 10000.
      IOUT(43) 10.
      IOUT(44) 10000.
      IOUT(45) 10.
      IOUT(46) 10000.
ETAL 1.4
BTV 1.5706
ENDNODAC                                                      MAIN 590
U 1200.
V 1000.
W 100.
PHI -.66667
PSI 4.
THE 0.25
P 2.0
Q 0.8
DEL1DT -100.
DEL2 10.
DEL2DT -100.
DEL1 10.
DELRDT -100.
DELR 10.
PHIRDT -10.
PHIR 1.
UDT -800.
VDT -1500.
R 4.
DELFW1 -0.5
DELFW2 -0.5
RDT -20.
      ARPS(1) -100.
      ARPS(2) -100.
      ARPS(3) -100.
      ARPS(4) -100.
S1P 1000.
S2P 1000.
ZETDRF 100.
ZETDLF 100.
ZETDRR 100.
ZETDLR 100.
QDT -2.
PDT -12.
WDT 200.
PHIDT -2.
THEDT -.25
PSIDT -2.
ENDNOADC                                                      MAIN 880
PARAM(341) 0.0
PARAM(342) 0.0
PARAM(343) 0.0
PARAM(344) 0.0
                                                              MAIN 890
INDXCN 1
                                                              MAIN 900
VEHICLE MODEL * DODGE CORONET 1971
-0.38     .1061661  .1684393  .01604185 -.00579372-.00220835 0.0
```

```
0.75      0.0      0.0      0.0      0.0      0.0      0.0            MAIN9110
-0.27     -.2416662 -.00944941.01291661 -.00089631-.00125   0.0
0.0       0.0      0.0      0.0      0.0      0.0      0.0
0.0       0.0      0.0      0.0      0.0      0.0      0.0            MAIN9140
0.0       0.0      0.0      0.0      0.0      0.0      0.0            MAIN9150
0.        0.          TABLE I - FRONT BRAKE TORQUE FUNCTION
1000.     20640.
99999.                                                                MAIN9190
0.        0.          TABLE II - REAR BRAKE TORQUE FUNCTION
1000.     20640.
99999.                                                                MAIN9230
0.         0.      TABLE III- SIDE FORCE SHAPING FUNCTION
.05        .01
.1         .03
.15        .07
.2         .17
.3         .35
.4         .54
.6         .81
.8         .93
1.         1.
99999.                                                                MAIN9410
-1000.    528.        WIND PROFILE
0.        528.
1000.     528.
99999.
0.0       0.0      0.0      0.0      0.0      0.0      0.0            AERO
99999.
0.0       0.0
99999.
0.0       0.0         STEER PROFILE
0.25      -13.6
1.25      -31.45
1.55      135.
1.75      125.46
2.0       62.73
2.3       -200.
2.5       -204.
6.        -204.
99999.
-10.0      -1688.        RIGHT FRONT SPRING DATA
-2.4       -252.
0.0        0.0
2.1        221.
10.0       4866.
99999.
-10.0      -1688.         LEFT FRONT SPRING DATA
-2.4       -252.
0.0        0.0
2.1        221.
10.0       4866.
99999.
-10.0      -2342.        RIGHT REAR SPRING DATA
-4.4       -528.
0.0        0.0
3.6        432.
10.0       5962.
99999.
-10.0      -2342.         LEFT REAR SPRING DATA
-4.4       -528.
```

```
0.0         0.0
3.6         432.
10.0        5962.
99999.
-100.       -433.          RIGHT FRONT SHOCK ABSORBER DATA
0.0         0.0
100.        936.
99999.
-100.       -433.           LEFT FRONT SHOCK ABSORBER DATA
0.0         0.0
100.        936.
99999.
-100.       -199.          RIGHT REAR SHOCK ABSORBER DATA
-7.2        -59.9
0.0         0.0
100.        663.
99999.
-100.       -199.           LEFT REAR SHOCK ABSORBER DATA
-7.2        -59.9
0.0         0.0
100.        663.
99999.
066  40.       40.       40.       30.       40.       45.       50.
074  0.        0.        0.        30.       0.        0.        0.
076  5.        10.       10.       5.        5.5       4.        3.
112                                          55.
114  62.       0.        82.       139.      0.        0.        0.
115  1.        0.        1.        1.        1.        0.        0.
116  .5        100.       .5        .5       .4        100.      100.
117  3.        0.        3.        0.        0.        0.        0.
118  3.        0.        3.        0.        0.        0.        0.
121  300.      200.      200.      0.        0.        0.        1000.
124  0.        0.        0.        0.        0.        2.        1.
125  0.        0.        0.        0.        0.        0.        1.
126  0.        0.        0.        0.        0.        1.        1.
128  3.        1.        3.        4.        2.        5.        6.
192  1.        .1        .1        .1        .1        .1        .05
198  0.        0.        0.        12.       0.        0.        0.
199  0.        0.        0.        57.6      0.        0.        0.
201  0.        0.        0.        1000.     0.        0.        0.
277  0.        0.        0.        8.        0.        0.        0.
278  0.        0.        0.        0.        0.        0.        .52
279  0.        0.        0.        0.        0.        0.        1.02
123  0.        0.        0.        0.        0.        0.        0.
123  0.        0.        0.        0.        0.        0.        0.
123  0.        0.        0.        0.        0.        0.        0.
123  0.        0.        0.        0.        0.        0.        0.
123  0.        0.        0.        0.        0.        0.        0.
123  0.        0.        0.        0.        0.        0.        0.
001  8.43
002  0.51
003  0.82
004  11.3
005  11.3
006  49.3
007  68.7
008  59.8
009  61.8
010  47.0
011  3758.
```

```
012  23047.
013  23327.
014  530.
015  550.
016 30.
017  40400.
018 10.
019 105.0
020 105.0
021 120.0
022 120.0                                                    MAIN9800
023  0.
024  -5100.
025 40.0
026 40.0
027 38.0
028 38.0
029 0.
030  0.020
031  13.2
032 1000.                                                    MAIN9900
033   0.75
034  2701.
035  10.14
036  2533.
037  1.30
038  4591.
039 0.0
040 0.0
041  8000.
042  14.2
043
044
045
046
047  6.4
048 0.0
049  9.4
050  9.4
051  0.7
052  2.71
053 0.0
054 0.0
055 -0.66
056  4.59
057 -4.59
058 -.1309
059  .1309
060  1.0
061 0.0
062 0.0                                                      MAIN0200
063                                                          MAIN0210
064                                                          MAIN0220
065
066  40.                                                     MAIN0240
067                                                          MAIN0250
068                                                          MAIN0260
069                                                          MAIN0270
070
071
```

```
072                                                     MAIN0290
073                                                     MAIN0300
074                                                     MAIN0310
075 .005
 76  5.0
077  1450.
078  1450.
079  1450.
080  1450.
081
082
083
084
085  -.00033
086  0.0
087  1.228
088  .0000000759
089                                                     MAIN0460
090                                                     MAIN0470
091   0.0                                               MAIN0480
092  -0.8
093 -.68
094                                                     MAIN0510
095                                                     MAIN0520
096                                                     MAIN0530
097                                                     MAIN0540
098                                                     MAIN0550
099                                                     MAIN0560
100                                                     MAIN0570
101                                                     MAIN0580
102                                                     MAIN0590
103                                                     MAIN0600
104                                                     MAIN0610
105                                                     MAIN0620
106                                                     MAIN0630
107   1.0                                               MAIN0640
108 0.5
109 0.0
110 0.0
111 0.0
112  0.0
113  1.                                                 MAIN0700
114 25.
115  1.0
116  0.5
117  3.
118  3.
119                                                     MAIN0760
120                                                     MAIN0770
121  300.
122                                                     MAIN0790
123                                                     MAIN0800
124                                                     MAIN0810
125                                                     MAIN0820
126                                                     MAIN0830
127                                                     MAIN0840
128  3.0
129 0.                                                  MAIN0860
130  0.06
131 .2792
```

```
132  55900.
133  55900.
134  6.62
135  6.62
136  11.0
137  54.
138  5.20
139 .00785
140 .00785                                                                        MAIN0980
141  0.
142 88.
143 .03
144 .04
145 .001
146 .10
147 .010
148 .001
149 .006
150 .001
151 .001
152 .0001
153 .0001
154 .0003
155 .0004
156 500.                                                                         MAIN1140
157                                                                              MAIN1150
158                                                                              MAIN1160
159                                                                              MAIN1170
160                                                                              MAIN1180
161                                                                              MAIN1190
162                                                                              MAIN1200
163                                                                              MAIN1210
164                                                                              MAIN1220
165                                                                              MAIN1230
166                                                                              MAIN1240
167                                                                              MAIN1250
168
169  73.
170  73.
171  73.                                                                         MAIN1290
172 2.                                                                           MAIN1300
173                                                                              MAIN1310
174                                                                              MAIN1320
175 0.25
176 1.                                                                           MAIN1340
177                                                                              MAIN1350
178
179
180 0.0
181
182  0.17
183  0.17
184  0.17
185  0.17
186 9.36
187 9.36
188 6.63
189 6.63                                                                         MAIN1470
190                                                                              MAIN1480
191
```

```
                                    MAIN1490
192  1.                             MAIN1500
193                                 MAIN1510
194                                 MAIN1520
195
196  0.
197  0.
198
199                                 MAIN1570
200  1.5
201
202  0.94
203  -.00008
204  0.94
205  -.00008
206  0.65
207  0.65
208 .03
209  0.
210  0.                             MAIN1680
211  0.0
212  0.
213  0.                             MAIN1710
214  0.
215  0.
216  0.
217  0.
218  0.
219  0.
220  0.
221  0.
222  0.
223 0.0
224  0.
225  0.
226  0.
227  0.
228  0.
229  0.
230  0.
231  400.
232  400.
233 1.0
234
235
236
237
238  1.
239  1.
240  .67
241  .67
242  -.0000393
243  -.0000332
244  .00000175
245  -.00033
246  0.0
247  1.228
248  .0000000759
249  -.00318
250  .00349
251  1.404
```

```
252  -.00318
253  .00349
254  1.404
255  0.0
256  -.0015
257  -.005244
258  -5.592
259  0.0
260  -.0015
261  -.005244
262  -5.592
263  -0.13
264  -.03
265  .0
266  0.15
267  .015
268  .0
269  0.089
270  .01
271  .0
272  0.0
273  .0
274  .0
275  0.0
276  0.0                                                          MAIN2340
277  0.                                                           MAIN2350
278  0.                                                           MAIN2360
279  0.                                                           MAIN2370
280  0.
281
282                                                               MAIN2400
283  0.
284  2.7
285  3.9
286  0.0
287  1.                                                           MAIN2450
288  0.
289  4.                                                           MAIN2470
290  0.75
291  2701.
292  10.14
293  2533.
294  1.30
295  4591.
001  8.82
004  10.9
005  10.8
006  50.5
007  67.5
011  3832.
012  24003.
013  24311.
092  -1.1
093 -1.08                                                         MAIN2660
304
./      ENDUP
```

G-1.3. Solid Front and Rear Suspension with Dual Rear Tires, Winnebago Motor Home

```
091 CARCAL  MOTOR
DELFW1 DELFW2
TAUC
CXC CYC CZC CLC CMC CNC
SFXS SFYS SFZS
SNPHIS SNTHES SNPSIS
SFXU SFYU
SNPHIU SNTHEU SNPSIU
PHIDT THEDT PSIDT
PHI THE PSI
PDT QDT RDT
P Q R
UDT VDT WDT
U V W

PFL AXAVE TIMDEC AYMAX SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)
 PFL AXAVE AYMAX BETDMX CUVRAT SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)      MAIN  50
      BMPN BMPS AYMAX RMAX CUVRAT BETDMX                                 MAIN  60
STR4 BETAMX BETDMX CUVRAT AYMAX RMAX PHIMAX
 STR5 AYMAX DEL BETAMX DELPSI PHIMAX UIN
PHIMAX PHIDMX RMAX ZIMX(1) ZIMX(2) ZIMX(3) ZIMX(4) UIN  BRKOFF           MAIN  90
 PFL AXAVE AYMAX BETDMX CUVRAT SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)      MAIN 100
IOUT(01) 50.
IOUT(02) 100.
IOUT(03) 50.
IOUT(04) 625.
      IOUT(05) .04
IOUT(06) 0.4
IOUT(07) 2.0
IOUT(08) 1.0
      IOUT(09) .8
IOUT(10) .003
IOUT(11) 0.25
IOUT(12) 0.25
IOUT(13) 1.25
IOUT(14) 0.1
      IOUT(15) .2
IOUT(16) 1.25
      IOUT(17) .01
IOUT(18) 1.25
      NOTUSED(1) 1.
      NOTUSED(1) 1.
      IOUT(21) -1000.
      IOUT(22) -1000.
      IOUT(23) -1000.
      IOUT(24) -1000.
      IOUT(25) 10000.
      IOUT(26) 10.
      IOUT(27) 400.
IOUT(28) 1000.
IOUT(29) -1000.
IOUT(30) 28.
      IOUT(31) 10.
      IOUT(32) 10.
IOUT(33) 20000.
IOUT(34) 20000.
IOUT(35) 20000.
IOUT(36) 20000.
ETAX 1.4
```

```
      IOUT(38) 10000.
      IOUT(39) 10000.
      IOUT(40) 10000.
      IOUT(41) 10000.
      IOUT(42) 10000.
      IOUT(43) 10.
      IOUT(44) 10000.
      IOUT(45) 10.
      IOUT(46) 10000.
ETAL 1.4
BTV 1.5706
ENDNODAC                                                                MAIN 590
U 1200.
V 1000.
W 100.
PHI -.66667
PSI 4.
THE 0.25
P 2.0
Q 0.8
DELFDT -100.
PHIF 1.
PHIFDT -10.
DELF 10.
DELRDT -100.
DELR 10.
PHIRDT -10.
PHIR 1.
UDT -800.
VDT -1500.
R 4.
DELFW1 -0.5
DELFW2 -0.5
RDT -20.
      ARPS(1) -100.
      ARPS(2) -100.
      ARPS(3) -100.
      ARPS(4) -100.
S1P 4000.
S2P 4000.
ZETDRF 100.
ZETDLF 100.
ZETDRR 100.
ZETDLR 100.
QDT -2.
PDT -12.
WDT 200.
PHIDT -2.
THEDT -.25
PSIDT -2.
ENDNOADC                                                                MAIN 880
PARAM(341) 0.0
PARAM(342) 0.0
PARAM(343) 0.0
PARAM(344) 0.0
                                                                        MAIN 890
INDXCN 1
                                                                        MAIN 900
VEHICLE MODEL * WINNEBAGO MOTOR HOME TYPE A (DODGE RM 400/158.5" WB)
0.0       0.0       0.0       0.0       0.0       0.0
```

```
0.0       0.0       0.0       0.0       0.0       0.0
0.0       0.0       0.0       0.0       0.0       0.0
0.0       0.0       0.0       0.0       0.0       0.0
0.0       0.0       0.0       0.0       0.0       0.0
0.0       0.0       0.0       0.0       0.0       0.0
0.0       0.0       TABLE I * BRAKE TORQUE FUNCTION
80.       0.0
1000.     53000.
1600.     75000.
99999.
0.0       0.0       TABLE II * BRAKE TORQUE FUNCTION
80.       0.0
1000.     53000.
1600.     75000.
99999.
0.         0.       TABLE III- SIDE FORCE SHAPING FUNCTION
.05        .01
.1         .03
.15        .07
.2         .17
.3         .35
.4         .54
.6         .81
.8         .93
1.         1.
99999.                                                                MAIN1180
1128.      0.0          WIND PROFILE DATA
1140.      1056.
1248.      1056.
1260.      0.0
99999.
0.0       .78       0.0       .15       0.0       .19       0.0       AERO
0.08727   .79       .33       .29       .12       .25       -.12
0.1745    .83       .58       .45       .20       .29       -.15
0.2618    .90       .90       .55       .34       .33       -.15
0.3491    .94       1.33      .84       .48       .35       -.15
0.4364    .94       1.82      1.11      .64       .37       -.17
1.6       0.0       0.0       0.0       0.0       0.0       0.0
3.14      0.0       0.0       0.0       0.0       0.0       0.0
99999.
0.0        0.0
.08727     0.0
.1745      0.0
.2618      0.0
.3491      0.0
.4364      0.0
1.6        0.0
3.14       0.0
99999.
0.0       0.0           STEER PROFILE DATA
0.25      -13.6
1.25      -31.45
1.55      135.
1.75      125.46
2.0       62.73
2.3       -200.
2.5       -204.
6.        -204.
99999.
-10.0     -6579.        RIGHT FRONT SPRING DATA
```

```
-2.3        -1035.0
0.0         0.0
3.1         1395.0
10.0        10089.
99999.
-10.0       -6579.         LEFT FRONT SPRING DATA
-2.3        -1035.0
0.0         0.0
3.1         1395.0
10.0        10089.
99999.
-10.0       -10366.5      RIGHT REAR SPRING DATA
-3.9        -3412.5
0.0         0.0
2.7         2362.5
10.0        15137.5
99999.
-10.0       -10366.5       LEFT REAR SPRING DATA
-3.9        -3412.5
0.0         0.0
2.7         2362.5
10.0        15137.5
99999.
-100.       -391.8        RIGHT FRONT SHOCK ABSORBER DATA
-8.4        -107.9
0.0         0.0
1.4         165.4
6.          280.5
100.        1182.9
99999.
-100.       -391.8         LEFT FRONT SHOCK ABSORBER DATA
-8.4        -107.9
0.0         0.0
1.4         165.4
6.          280.5
100.        1182.9
99999.
-100.       -799.8        RIGHT REAR SHOCK ABSORBER DATA
-9.8        -34.
0.0         0.0
0.8         58.8
4.4         108.3
100.        618.8
99999.
-100.       -799.8         LEFT REAR SHOCK ABSORBER DATA
-9.8        -34.
0.0         0.0
0.8         58.8
4.4         108.3
100.        618.8
99999.
066  40.        40.        40.        30.        40.        45.        50.
074  0.         0.         0.         30.        0.         0.         0.
076  5.         10.        10.        5.         5.5        4.         3.
114  62.        0.         62.        77.        0.         0.         0.
115  1.         0.         1.         1.         1.         0.         0.
116  .5         100.        .5         .5        .4         100.       100.
117  3.         0.         3.         0.         0.         0.         0.
118  3.         0.         3.         0.         0.         0.         0.
121  300.       200.       200.       0.         0.         0.         1000.
```

124	0.	0.	0.	0.	0.	2.5	1.
125	0.	0.	0.	0.	0.	0.	1.
126	0.	0.	0.	0.	0.	1.	1.
128	3.	1.	3.	4.	2.	5.	6.
192	1.	.1	.1	.1	.1	.1	.05
198	0.	0.	0.	12.	0.	0.	0.
199	0.	0.	0.	57.6	0.	0.	0.
201	0.	0.	0.	1000.	0.	0.	0.
277	0.	0.	0.	8.	0.	0.	0.
278	0.	0.	0.	0.	0.	0.	.52
279	0.	0.	0.	0.	0.	0.	1.02
123	0.	0.	0.	0.	0.	0.	0.
123	0.	0.	0.	0.	0.	0.	0.
123	0.	0.	0.	0.	0.	0.	0.
123	0.	0.	0.	0.	0.	0.	0.
123	0.	0.	0.	0.	0.	0.	0.
123	0.	0.	0.	0.	0.	0.	0.
123	0.	0.	0.	0.	0.	0.	0.

001	24.609	
002	1.721	
003	2.888	
004	36.30	
005	36.19	
006	99.41	
007	59.09	
008	66.15	
009	66.12	
010	41.24	
011	40300.	
012	219100.	
013	216500.	
014	7100.	
015	2400.	
016	30.	
017	153000.	
018	10.	
019	450.	
020	450.	
021	875.	
022	875.	
023	0.	MAIN1820
024	153000.	
025	100.	
026	100.	
027	150.	
028	150.	
029	0.0	
030	-.01	
031	16.87	
032	4000.	
033	1.0	
034	635.2	
035	11.98	
036	5447.9	
037	1.89	
038	6306.2	
039	56.62	
040	75.62	
041	8000.	
042	17.5	

```
043
044
045
046
047 27.0
048 1500.
049 21.3
050 48.0
051 1.30
052 4.56
053 31.0
054 .07
055 1.31
056 6.08
057 -6.08
058 -.12217
059 .12217                                        MAIN2190
060  1.0
061 0.
062 0.                                            MAIN2220
063                                               MAIN2230
064                                               MAIN2240
065                                               MAIN2250
066  40.                                          MAIN2260
067                                               MAIN2270
068                                               MAIN2280
069                                               MAIN2290
070                                               MAIN2300
071                                               MAIN2310
072                                               MAIN2320
073                                               MAIN2330
074
075 .005                                          MAIN2350
 76  5.0
077 3040.
078 3040.
079 3040.
080 3040.                                         MAIN2400
081                                               MAIN2410
082                                               MAIN2420
083                                               MAIN2430
084
085 -.000236
086 0.0
087 1.32
088 .0000000297                                   MAIN2480
089                                               MAIN2490
090                                               MAIN2500
091   0.0
092 0.0
093 0.0                                           MAIN2530
094                                               MAIN2540
095                                               MAIN2550
096                                               MAIN2560
097                                               MAIN2570
098                                               MAIN2580
099                                               MAIN2590
100                                               MAIN2600
101                                               MAIN2610
102
```

```
                                   MAIN2620
                                   MAIN2630
                                   MAIN2640
                                   MAIN2650
   1.0                             MAIN2660
.4                                 MAIN2670
0.0
 4428.                             MAIN2690
 738.                              MAIN2700
 0.0                               MAIN2710
 1.                                MAIN2720
 62.                               MAIN2730
 1.0                               MAIN2740
 0.5                               MAIN2750
 3.                                MAIN2760
 3.                                MAIN2770
0.0
0.0
 300.                              MAIN2800
                                   MAIN2810
                                   MAIN2820
                                   MAIN2830
                                   MAIN2840
                                   MAIN2850
                                   MAIN2860
 3.0                               MAIN2870
0.                                 MAIN2880
.078
.279
150000.
150000.
8.02
8.02
11.
120.
7.50
.009
-.009
 0.                                MAIN3000
0.0                                MAIN3010
0.
0.
.0000001147
0.0
0.0                                MAIN3060
0.0                                MAIN3070
0.0                                MAIN3080
0.0                                MAIN3090
0.0                                MAIN3100
0.0                                MAIN3110
0.0                                MAIN3120
0.0                                MAIN3130
0.0                                MAIN3140
9100.
294.
1094.
                                   MAIN3180
                                   MAIN3190
                                   MAIN3200
                                   MAIN3210
```

```
163                                                      MAIN3220
164                                                      MAIN3230
165                                                      MAIN3240
166                                                      MAIN3250
167                                                      MAIN3260
168                                                      MAIN3270
169 73.
170 75.
171 75.                                                  MAIN3300
172 2.                                                   MAIN3310
173                                                      MAIN3320
174                                                      MAIN3330
175 0.25                                                 MAIN3340
176 1.
177                                                      MAIN3360
178                                                      MAIN3370
179
180 0.0
181
182 .20
183 .20
184 .20
185 .20
186 118.15
187 118.15
188 73.5
189 73.5
190                                                      MAIN3490
191                                                      MAIN3500
192  1.                                                  MAIN3510
193                                                      MAIN3520
194                                                      MAIN3530
195                                                      MAIN3540
 196 -.0018
197 .0018
198                                                      MAIN3570
199                                                      MAIN3580
200  1.5                                                 MAIN3590
201                                                      MAIN3600
202 1.04
203 -.0000758
204 1.04
205 -.0000758
206 .72
207 .72
208 .03
209  0.                                                  MAIN3680
210  0.                                                  MAIN3690
211  0.0                                                 MAIN3700
212  0.                                                  MAIN3710
213  0.                                                  MAIN3720
214  0.                                                  MAIN3730
215  0.                                                  MAIN3740
216  0.                                                  MAIN3750
217  0.                                                  MAIN3760
218  0.                                                  MAIN3770
219 .0349
220 -0.0349
221 .0698
222 .0698
```

```
 0.                MAIN3820
 0.                MAIN3830
 0.                MAIN3840
 0.                MAIN3850
 0.                MAIN3860
 0.                MAIN3870
 0.                MAIN3880
 0.                MAIN3890
600.
600.
0.
1.13
1.13
1.0
1.0
-.000020
-.000020
.0000015
-.000236
0.0
1.32
.0000000297
-.00157
.00148
1.608
-.00157
.00148
1.608
0.0
-.000624
.00240
-9.132
0.0
-.000624
.00240
-9.132
0.
0.
0.
0.
0.
0.
0.
0.
0.
0.
0.
0.
 0.0
 0.0
 0.
 0.
 0.                MAIN4380
 0.                MAIN4390
```

```
                                                                 MAIN4420
283  0.
284 0.
285 0.                                                           MAIN4450
286  0.0
287 0.
288 1.
289 6.
290 1.0
291 635.2
292 11.98
293 5447.9
294 1.89
295 6306.2                                                       MAIN4550
304
./     ENDUP
```

G-2. Wheel Spring and Shock Absorber Characteristics

G-2.1 Wheel Spring Characteristics

The entries in this table are the values of the slopes versus suspension displacement for the no-load (curb weight) vehicle configuration. The units of the entries are lb/in. and in.

Vehicle	Spring Force Effective at the Wheel for the Independent Front Suspension and at the Spring Location for the Solid Front Axle	Spring Force Effective at the Wheel for the Independent Rear Suspension and at the Spring Location for the Solid Rear Axle
VW Campmobile	935 for $\delta \geq 0.43$ 129 for $-3.74 < \delta < 0.43$ 361 for $-4.92 < \delta \leq -3.74$ 896 for $-5.67 < \delta \leq -4.92$ 4413 for $\delta \leq -5.67$	991 for $\delta \geq 2.28$ 213 for $-1.57 < \delta < 2.28$ 328 for $-3.54 < \delta \leq -1.57$ 454 for $-4.61 < \delta \leq -3.54$ 2766 for $\delta \leq -4.61$
Dodge Coronet	558 for $\delta > 2.1$ 105 for $-2.4 < \delta < 2.1$ 189 for $\delta < -2.4$	864 for $\zeta \geq 3.6$ 120 for $-4.4 < \zeta < 3.6$ 324 for $\zeta \leq -4.4$
Winnebago Motor Home	1260 for $\zeta \geq 3.1$ 450 for $-2.3 < \zeta < 3.1$ 720 for $\zeta \leq -2.3$	1750 for $\zeta \geq 2.7$ 875 for $-3.9 < \zeta < 2.7$ 1140 for $\zeta \leq -3.9$

G-2.2 Shock Absorber Characteristics

The entries in this table are the values of the slopes versus suspension velocity. The units of the entries are lb/(in./s) and in./s.

Vehicle	Viscous Damping Force Effective at the Wheel for the Independent Front Suspension and at the Spring Location for the Solid Front Axle	Viscous Damping Force Effective at the Wheel for the Independent Rear Suspension and at the Spring Location for the Solid Rear Axle
VW Campmobile	5.14 for $\dot{\delta} \geq 11.8$ 17.63 for $3.0 \leq \dot{\delta} < 11.8$ 9.55 for $0 \leq \dot{\delta} < 3.0$ 4.06 for $-15.0 \leq \dot{\delta} < 0$ 2.09 for $\dot{\delta} < -15.0$	11.24 for $\dot{\delta} > 9.8$ 35.60 for $4.2 \leq \dot{\delta} < 9.8$ 22.86 for $0 \leq \dot{\delta} < 4.2$ 7.93 for $-10.6 \leq \dot{\delta} < 0$ 2.49 for $\dot{\delta} < -10.6$
Dodge Coronet	9.36 for $\dot{\delta} \geq 0$ 4.33 for $\dot{\delta} < 0$	6.63 for $\dot{\zeta} \geq 0$ 8.32 for $-7.2 < \dot{\zeta} < 0$ 1.50 for $\dot{\zeta} < -7.2$
Winnebago Motor Home	9.6 for $\dot{\zeta} \geq 6.0$ 25.02 for $1.4 \leq \dot{\zeta} < 6.0$ 118.15 for $0 \leq \dot{\zeta} < 1.4$ 12.84 for $-8.4 \leq \dot{\zeta} < 0$ 3.10 for $\dot{\zeta} < -8.4$	5.34 for $\dot{\zeta} \geq 4.4$ 13.76 for $0.8 \leq \dot{\zeta} < 4.4$ 73.50 for $0 \leq \dot{\zeta} < 0.8$ 3.47 for $-9.8 \leq \dot{\zeta} < 0$ 8.49 for $\dot{\zeta} < -9.8$

G-3. Camber, Caster, and Toe Data

To obtain these data, the wheel was moved from the full rebound position to compression bump stop. In order to use these data in calculations, one must know the values of camber, caster, and toe at a reference value of suspension displacement that depends upon vehicle loading. The units of the entries are in. and deg. The data presented here were measured with reference to a no-load (curb weight) vehicle configuration.

Vehicle	Displacement	Camber	Caster	Toe
VW Campmobile (right front wheel) (static displacement = 0.0)	0.5 0.0 -1.0 -2.0 -3.0 -4.0 -5.0 -5.5	1.00 0.95 0.90 0.80 0.70 0.60 0.50 0.35	2.67 2.77 2.85 2.95 3.00 3.05 3.08 3.05	-0.10 -0.07 -0.05 -0.02 0.00 0.03 0.07 0.10
VW Campmobile (right rear wheel) (static displacement = 0.0)	2.5 2.0 1.0 0.0 -1.0 -2.0 -3.0 -4.0 -4.5	0.80 0.45 -3.00 -1.00 -1.75 -2.50 -3.35 -4.25 -4.85	0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00	-0.333 -0.258 -0.146 -0.050 0.000 0.000 -0.004 -0.075 -0.162
Dodge Coronet (left front wheel) (static displacement = 3.0)	0. 1. 2. 3. 4. 5. 6.	0 0.41 0.98 1.26 1.22 0.95 0.43	0.75 0.00 0.00 0.00 0.00 0.00 0.00	0 -0.37 -0.59 -0.85 -1.05 -1.21 -1.36
Winnebago Motor Home	The attitudes of the wheels of a solid axle suspension are evaluated from axle angular displacement, suspension geometry (roll steer), and suspension compliance.			

```
PARAMETER VALUES - MODEL C - VEHICLE MODEL # VW CAMPMOBILE 1973
  1    MS=  8.6000     ,   2    MUF= 0.50700     ,   3    MUR= 0.48900     ,   4     ZF=  19.980     ,   5     ZR=  19.920     ,
  6     A=  49.650     ,   7      B=  44.850     ,   8     TF=  54.800     ,   9     TR=  57.200     ,  10    TSR= 0.0        ,
 11    IX=  7380.0     ,  12     IY=  24980.     ,  13     IZ=  25660.     ,  14    IXZ=  1140.0     ,  15     IR= 0.69697E 06,
 16  ROOR=  30.000     ,  17     RF= 0.15300E 06,  18   STOP=  10.000     ,  19   AKF1=  129.00     ,  20   AKF2=  129.00     ,
 21  AKR3=  213.00     ,  22   AKR4=  213.00     ,  23    ALS= 0.0        ,  24     RR= 0.0        ,  25   CF1P=  33.000     ,
 26  CF2P=  33.000     ,  27   CR3P=  56.000     ,  28   CR4P=  56.000     ,  29   ZBAS= 0.0        ,  30    KRS= 0.0        ,
 31    RW=  12.750     ,  32   SCAL=  2000.0     ,  33    FOT= 0.50000     ,  34     A0=  4566.6     ,  35     A1=  7.8700     ,
 36    A2=  2303.6     ,  37     A3= 0.29400     ,  38     A4= -1747.4     ,  39   TIR = 0.0        ,  40   TOR = 0.0        ,
 41   KSC=  8592.0     ,  42     NG=  16.300     ,  43    TSD= 0.0        ,  44   DSLM= 0.0        ,  45    TFT= 0.0        ,
 46  DSW2= 0.0         ,  47    IFW=  8.2700     ,  48    IF = 0.69697E 06,  49    IWF=  8.9300     ,  50    IWR=  9.2800     ,
 51   IDR= 0.30000     ,  52    ARR=  5.3750     ,  53   TSF = 0.0        ,  54   KFS = 0.0        ,  55     PT= 0.59000     ,
 56  YSA1=  3.4700     ,  57   YSA2= -3.4700     ,  58   PHS1=-0.87300E-01,  59   PHS2= 0.87300E-01,  60   CTSW=  1.0000     ,
 61   IDF= 0.0         ,  62    ARF= 0.0        ,  63   P-IN= 0.0        ,  64   Q-IN= 0.0        ,  65   R-IN= 0.0        ,
 66  U-IN=  40.000     ,  67   V-IN= 0.0        ,  68   W-IN= 0.0        ,  69   X-IN= 0.0        ,  70   Y-IN= 0.0        ,
 71  Z-IN= -31.659     ,  72   THIN= 0.91247E-01,  73   PHIN= 0.0        ,  74   PSIN= 0.0        ,  75     DT= 0.10000E-01,
 76    TN=  5.0000     ,  77    KT1=  894.00     ,  78    KT2=  894.00     ,  79    KT3=  894.00     ,  80    KT4=  894.00     ,
 81  RPS1= 0.0         ,  82   RPS2= 0.0        ,  83   RPS3= 0.0        ,  84   RPS4= 0.0        ,  85     B1=-0.20560E-03,
 86    B2= 0.0         ,  87     B3=  1.0450     ,  88     B4= 0.39910E-07,  89   D1DT= 0.0        ,  90   D2DT= 0.0        ,
 91  D3DT= 0.0         ,  92   DELF= -1.5400     ,  93   DELR= -1.0300     ,  94   DEL3= 0.0        ,  95   PHDT= 0.0        ,
 96  PHIR= 0.0         ,  97   DFW1= 0.0        ,  98   DFW2= 0.0        ,  99   U1PR= 0.0        , 100   U2PR= 0.0        ,
101  U3PR= 0.0         , 102   U4PR= 0.0        , 103   S1PR= 0.0        , 104   S2PR= 0.0        , 105   S3PR= 0.0        ,
106  S4PR= 0.0         , 107   PPRT=  1.0000     , 108   FREQ= 0.40000     , 109       = 0.0        , 110   TQMX=  4428.0     ,
111   KTQ=  738.00     , 112     VC=  50.000     , 113   MTSW=  1.0000     , 114   DSWM=  62.000     , 115    TST=  1.0000     ,
116  DSLP= 0.50000     , 117   CGAM=  3.0000     , 118     CS=  3.0000     , 119    TQR= 0.0        , 120    TQF= 0.0        ,
121   PFL=  300.00     , 122    TTD= 0.0        , 123   DSW1= 0.0        , 124       = 0.0        , 125   ISW5= 0.0        ,
126  SW15= 0.0         , 127       = 0.0        , 128   VTPS=  3.0000     , 129   VHTP= 0.0        , 130   AMCR= 0.38000E-01,
131   ESP= 0.32000     , 132   KSL1=  44000.     , 133   KSL2=  44000.     , 134    AA1=  6.2000     , 135    AA2=  6.2000     ,
136   CCR=  17.600     , 137   CFCR=  126.00     , 138     AP=  5.6800     , 139    EP1= 0.10000E-01, 140    EP2=-0.10000E-01,
141  AERO= 0.0         , 142   VYW = 0.0        , 143   OMXW= 0.0        , 144   OMZW= 0.0        , 145   RHOA= 0.11470E-06,
146   CYP = 0.0        , 147   CYR = 0.0        , 148   CZAL= 0.0        , 149   CZQ = 0.0        , 150   CLP = 0.0        ,
151   CLR = 0.0        , 152   CMAL= 0.0        , 153   CMQ = 0.0        , 154   CNP = 0.0        , 155   CNR = 0.0        ,
156   SF  =  4233.6    , 157   VLEN=  94.500     , 158   REWV=  1094.0     , 159       = 0.0        , 160       = 0.0        ,
161       = 0.0        , 162       = 0.0        , 163       = 0.0        , 164       = 0.0        , 165       = 0.0        ,
166       = 0.0        , 167       = 0.0        , 168       = 0.0        , 169    SNT=  73.000     , 170   SNS0=  75.000     ,
171  SNS1=  75.000     , 172   SNSW=  2.0000     , 173   DIST= 0.0        , 174    PL = 0.0        , 175   TSCP= 0.99850     ,
176  SCSW=  1.0000     , 177       = 0.0        , 178       = 0.0        , 179       = 0.0        , 180       = 0.0        ,
181       = 0.0        , 182    SI1= 0.13000     , 183    SI2= 0.13000     , 184    SI3= 0.13000     , 185    SI4= 0.13000     ,
186  SARF=  27.600     , 187   SALF=  27.600     , 188   SARR=  10.600     , 189   SALR=  10.600     , 190       = 0.0        ,
191       = 0.0        , 192   MTQB=  1.0000     , 193   DCSW= 0.0        , 194    LDF=  100.00     , 195   LDRF=  1200.0     ,
196   EK1= 0.0         , 197    EK2= 0.0        , 198   BMPL= 0.0        , 199   BMPS= 0.0        , 200   BMPH=  1.5000     ,
201    XB= 0.0         , 202   APF1= 0.89880     , 203   APF2=-0.94970E-04, 204   APR1= 0.89880     , 205   APR2=-0.94970E-04,
206  MUSF= 0.67700     , 207   MUSR= 0.67700     , 208   RCON= 0.30000E-01, 209   FCSW= 0.0        , 210   S1F =-0.32260E-04,
211  S1R =-0.32260E-04 , 212   KLR = 0.0        , 213   KOTF= 0.0        , 214   KOTR= 0.0        , 215       =  100.00     ,
216       =  100.00    , 217       =  1.0000     , 218       = 0.0        , 219   FEE1= 0.0        , 220   FEE2= 0.0        ,
221  THE1= 0.0         , 222   THE2= 0.0        , 223   ALMC= 0.0        , 224       = 0.0        , 225       = 0.0        ,
226       = 0.0        , 227       = 0.0        , 228       = 0.0        , 229       = 0.0        , 230       = 0.0        ,
231    H1=  400.00     , 232     H2=  400.00     , 233   LAMD=  1.0000     , 234       = 0.0        , 235       = 0.0        ,
236  PS01= 0.0         , 237   PS02= 0.0        , 238    BR1=  1.9000     , 239    BR2=  1.9000     , 240    BR3=  1.0000     ,
241   BR4=  1.0000     , 242    KCF=-0.37200E-04, 243    KCR=-0.22000E-04, 244    KSR= 0.20000E-05, 245    RB1=-0.20560E-03,
246   RB2= 0.0         , 247    RB3=  1.0450     , 248    RB4= 0.39910E-07, 249   AFK1=-0.31764E-02, 250   AFK2= 0.29568E-02,
251  AFK3= 0.66000     , 252   ARK1=-0.31764E-02, 253   ARK2= 0.29568E-02, 254   ARK3= 0.66000     , 255   OFC0= 0.0        ,
256  OFC1=-0.13020E-02 , 257   OFC2=-0.27288E-02, 258   OFC3= -5.7960     , 259   ORC0= 0.0        , 260   ORC1=-0.13020E-02,
261  ORC2=-0.27288E-02 , 262   ORC3= -5.7960     , 263   CP0F= 0.0        , 264   CP1F= 0.0        , 265   CP2F= 0.0        ,
266  CP0R= 0.29000     , 267   CP1R= 0.30000E-01, 268   CP2R= 0.0        , 269   CR0F= 0.0        , 270   CR1F= 0.0        ,
271  CR2F= 0.0         , 272   CR0R= 0.13000     , 273   CR1R= 0.30000E-01, 274   CR2R= 0.0        , 275   STSW= 0.0        ,
276  MMSW= 0.0         , 277   BMPN= 0.0        , 278   TQB0= 0.0        , 279   TQB1= 0.0        , 280       = 0.0        ,
281       = 0.0        , 282       = 0.0        , 283       = 0.0        , 284    HFC= 0.0        , 285    HRC=  3.5600     ,
286  DRSW= 0.0         , 287   AXLE=  2.0000     , 288   DUAL= 0.0        , 289   TIRE=  4.0000     , 290   ROT = 0.50000     ,
291  RA0 =  4566.6     , 292   RA1 =  7.8700     , 293   RA2 =  2303.6     , 294   RA3 = 0.29400     , 295   RA4 = -1747.4     ,
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PARAMETER VALUES - MODEL C - VEHICLE MODEL * DODGE CORONET 1971
  1    MS=  8.8200      ,  2    MUF= 0.51000      ,  3    MUR= 0.82000      ,  4    ZF=  10.900       ,  5    ZR=  10.800       ,
  6    A=  50.500       ,  7    B=  67.500        ,  8    TF=  59.800       ,  9    TR=  61.800       , 10    TSR=  47.000      ,
 11    IX=  3832.0      , 12    IY=  24003.       , 13    IZ=  24311.       , 14    IXZ=  530.00      , 15    IR=  -550.00      ,
 16    ROOR=  30.000    , 17    RF=  40400.       , 18    STOP=  10.000     , 19    AKF1=  105.00     , 20    AKF2=  105.00     ,
 21    AKR3=  120.00    , 22    AKR4=  120.00     , 23    ALS= 0.0          , 24    RR= -5100.0       , 25    CF1P=  40.000     ,
 26    CF2P=  40.000    , 27    CR3P=  38.000     , 28    CR4P=  38.000     , 29    ZBAS= 0.0         , 30    KRS= 0.20000E-01,
 31    RW=  13.200      , 32    SCAL=  1000.0     , 33    FOT= 0.75000      , 34    A0=  2701.0       , 35    A1=  10.140       ,
 36    A2=  2533.0      , 37    A3=  1.3000       , 38    A4=  4591.0       , 39    T1R = 0.0         , 40    TOR = 0.0         ,
 41    KSC=  8000.0     , 42    NG=  14.200       , 43    TSD= 0.0          , 44    DSLM= 0.0         , 45    TFT= 0.0          ,
 46    DSW2= 0.0        , 47    IFW=  6.4000      , 48    IF = 0.0          , 49    IWF=  9.4000      , 50    IWR=  9.4000      ,
 51    IDR= 0.70000     , 52    ARR=  2.7100      , 53    TSF = 0.0         , 54    KFS = 0.0         , 55    PT=-0.66000       ,
 56    YSA1=  4.5900    , 57    YSA2= -4.5900     , 58    PHS1=-0.13090     , 59    PHS2= 0.13090     , 60    CTSW=  1.0000     ,
 61    IDF= 0.0         , 62    ARF= 0.0          , 63    P-IN= 0.0         , 64    Q-IN= 0.0         , 65    R-IN= 0.0         ,
 66    U-IN=  40.000    , 67    V-IN= 0.0         , 68    W-IN= 0.0         , 69    X-IN= 0.0         , 70    Y-IN= 0.0         ,
 71    Z-IN= -23.372    , 72    THIN=-0.13596E-01, 73    PHIN= 0.0         , 74    PSIN= 0.0         , 75    DT= 0.50000E-02,
 76    TN=  5.0000      , 77    KT1=  1450.0      , 78    KT2=  1450.0      , 79    KT3=  1450.0      , 80    KT4=  1450.0      ,
 81    RPS1=  56.502    , 82    RPS2=  56.502     , 83    RPS3=  55.927     , 84    RPS4=  55.927     , 85    B1=-0.33000E-03,
 86    B2= 0.0          , 87    B3=  1.2280       , 88    B4= 0.75900E-07, 89    D1DT= 0.0         , 90    D2DT= 0.0         ,
 91    D3DT= 0.0        , 92    DELF= -1.1000     , 93    DELR= -1.0800     , 94    DEL3= 0.0         , 95    PHDT= 0.0         ,
 96    PHIR= 0.0        , 97    DFW1= 0.0         , 98    DFW2= 0.0         , 99    U1PR= 0.0         , 100   U2PR= 0.0         ,
101    U3PR= 0.0        , 102   U4PR= 0.0         , 103   S1PR= 0.0         , 104   S2PR= 0.0         , 105   S3PR= 0.0         ,
106    S4PR= 0.0        , 107   PPRT=  1.0000     , 108   FREQ= 0.50000     , 109        = 0.0        , 110   TQMX= 0.0         ,
111    KTQ= 0.0         , 112   VC= 0.0           , 113   MTSW=  1.0000     , 114   DSWM=  62.000     , 115   TST=  1.0000      ,
116    DSLP= 0.50000    , 117   CGAM=  3.0000     , 118   CS=  3.0000       , 119   TQR= 0.0          , 120   TQF= 0.0          ,
121    PFL=  300.00     , 122   TTD= 0.0          , 123   DSW1= 0.0         , 124        = 0.0        , 125   ISW5= 0.0         ,
126    SW15= 0.0        , 127        = 0.0        , 128   VTPS=  3.0000     , 129   VHTP= 0.0         , 130   AMCR= 0.60000E-01,
131    ESP= 0.27920     , 132   KSL1=  55900.     , 133   KSL2=  55900.     , 134   AA1=  6.6200      , 135   AA2=  6.6200      ,
136    CCR=  11.000     , 137   CFCR=  54.000     , 138   AP=  5.2000       , 139   EP1= 0.78500E-02, 140   EP2= 0.78500E-02,
141    AERO= 0.0        , 142   VYW =  88.000     , 143   OMXW= 0.30000E-01, 144   OMZW= 0.40000E-01, 145   RHOA= 0.10000E-02,
146    CYP = 0.10000E 00, 147   CYR = 0.10000E-01, 148   CZAL= 0.10000E-02, 149   CZQ = 0.60000E-02, 150   CLP = 0.10000E-02,
151    CLR = 0.10000E-02, 152   CMAL= 0.10000E-03, 153   CMQ = 0.10000E-03, 154   CNP = 0.30000E-03, 155   CNR = 0.40000E-03,
156    SF  =  500.00    , 157   VLEN= 0.0         , 158   REWV= 0.0         , 159        = 0.0        , 160        = 0.0        ,
161         = 0.0       , 162        = 0.0        , 163        = 0.0        , 164        = 0.0        , 165        = 0.0        ,
166         = 0.0       , 167        = 0.0        , 168        = 0.0        , 169   SNT=  73.000      , 170   SNS0=  73.000     ,
171    SNS1=  73.000    , 172   SNSW=  2.0000     , 173   DIST= 0.0         , 174   PL  = 0.0         , 175   TSCP= 0.25000     ,
176    SCSW=  1.0000    , 177        = 0.0        , 178        = 0.0        , 179        = 0.0        , 180        = 0.0        ,
181         = 0.0       , 182   SI1= 0.17000      , 183   SI2= 0.17000      , 184   SI3= 0.17000      , 185   SI4= 0.17000      ,
186    SARF=  9.3600    , 187   SALF=  9.3600     , 188   SARR=  6.6300     , 189   SALR=  6.6300     , 190        = 0.0        ,
191         = 0.0       , 192   MTQB=  1.0000     , 193   DCSW= 0.0         , 194   LDF= 0.0          , 195   LDRF= 0.0         ,
196    EK1= 0.0         , 197   EK2= 0.0          , 198   BMPL= 0.0         , 199   BMPS= 0.0         , 200   BMPH=  1.5000     ,
201    XB= 0.0          , 202   APF1= 0.94000     , 203   APF2=-0.80000E-04, 204   APR1= 0.94000     , 205   APR2=-0.80000E-04,
206    MUSF= 0.65000    , 207   MUSR= 0.65000     , 208   BCON= 0.30000E-01, 209   FCSW= 0.0         , 210   S1F = 0.0         ,
211    S1R = 0.0        , 212   KLR = 0.0         , 213   KOTF= 0.0         , 214   KOTR= 0.0         , 215        = 0.0        ,
216         = 0.0       , 217        = 0.0        , 218        = 0.0        , 219   FEE1= 0.0         , 220   FEE2= 0.0         ,
221    THE1= 0.0        , 222   THE2= 0.0         , 223   ALMC= 0.0         , 224        = 0.0        , 225        = 0.0        ,
226         = 0.0       , 227        = 0.0        , 228        = 0.0        , 229        = 0.0        , 230        = 0.0        ,
231    H1=  400.00      , 232   H2=  400.00       , 233   LAMD=  1.0000     , 234        = 0.0        , 235        = 0.0        ,
236    PS01= 0.0        , 237   PS02= 0.0         , 238   BR1=  1.0000      , 239   BR2=  1.0000      , 240   BR3= 0.67000      ,
241    BR4= 0.67000     , 242   KCF=-0.39300E-04, 243   KCR=-0.33200E-04, 244   KSR= 0.17500E-05, 245   RB1=-0.33000E-03,
246    RB2= 0.0         , 247   RB3=  1.2280      , 248   RB4= 0.75900E-07, 249   AFK1=-0.31800E-02, 250   AFK2= 0.34900E-02,
251    AFK3=  1.4040    , 252   ARK1=-0.31800E-02, 253   ARK2= 0.34900E-02, 254   ARK3=  1.4040     , 255   OFC0= 0.0         ,
256    OFC1=-0.15000E-02, 257   OFC2=-0.52440E-02, 258   OFC3= -5.5920     , 259   ORC0= 0.0         , 260   ORC1=-0.15000E-02,
261    ORC2=-0.52440E-02, 262   ORC3= -5.5920     , 263   CP0F=-0.13000     , 264   CP1F=-0.30000E-01, 265   CP2F= 0.0         ,
266    CP0R= 0.15000    , 267   CP1R= 0.15000E-01, 268   CP2R= 0.0         , 269   CR0F= 0.89000E-01, 270   CR1F= 0.10000E-01,
271    CR2F= 0.0        , 272   CR0R= 0.0         , 273   CR1R= 0.0         , 274   CR2R= 0.0         , 275   STSW= 0.0         ,
276    MMSW= 0.0        , 277   BMPN= 0.0         , 278   TQB0= 0.0         , 279   TQB1= 0.0         , 280        = 0.0        ,
281         = 0.0       , 282        = 0.0        , 283        = 0.0        , 284   HFC=  2.7000      , 285   HRC=  3.9000      ,
286    DRSW= 0.0        , 287   AXLE=  1.0000     , 288   DUAL= 0.0         , 289   TIRE=  4.0000     , 290   ROT = 0.75000     ,
2991   RA0 =  2701.0    , 292   RA1 =  10.140     , 293   RA2 =  2533.0     , 294   RA3 =  1.3000     , 295   RA4 =  4591.0     ,
```

PARAMETER VALUES - MODEL C - VEHICLE MODEL * WINNEBAGO MOTOR HOME TYPE A (DODGE RM 400/158.5" WB)

1	MS= 24.609	2	MUF= 1.7210	3	MUR= 2.8880	4	ZF= 36.300	5	ZR= 36.190
6	A= 99.410	7	B= 59.090	8	TF= 66.150	9	TR= 66.120	10	TSR= 41.240
11	IX= 40300.	12	IY= 0.21910E 06	13	IZ= 0.21650E 06	14	IXZ= 7100.0	15	IR= 2400.0
16	ROOR= 30.000	17	RF= 0.15300E 06	18	STOP= 10.000	19	AKF1= 450.00	20	AKF2= 450.00
21	AKR3= 875.00	22	AKR4= 875.00	23	ALS= 0.0	24	RR= 0.15300E 06	25	CF1P= 100.00
26	CF2P= 100.00	27	CR3P= 150.00	28	CR4P= 150.00	29	ZBAS= 0.0	30	KRS=-0.10000E-01
31	RW= 16.870	32	SCAL= 4000.0	33	FOT= 1.0000	34	A0= 635.20	35	A1= 11.980
36	A2= 5447.9	37	A3= 1.8900	38	A4= 6306.2	39	TIR = 56.620	40	TOR = 75.620
41	KSC= 8000.0	42	NG= 17.500	43	TSD= 0.0	44	DSLM= 0.0	45	TFT= 0.0
46	DSW2= 0.0	47	IFW= 27.000	48	IF = 1500.0	49	IWF= 21.300	50	IWR= 48.000
51	IDR= 1.3000	52	ARR= 4.5600	53	TSF = 31.000	54	KFS = 0.70000E-01	55	PT= 1.3100
56	YSA1= 6.0800	57	YSA2= -6.0800	58	PHS1=-0.12217	59	PHS2= 0.12217	60	CTSW= 1.0000
61	IDF= 0.0	62	ARF= 0.0	63	P-IN= 0.0	64	Q-IN= 0.0	65	R-IN= 0.0
66	U-IN= 40.000	67	V-IN= 0.0	68	W-IN= 0.0	69	X-IN= 0.0	70	Y-IN= 0.0
71	Z-IN= -52.478	72	THIN=-0.77222E-04	73	PHIN= 0.0	74	PSIN= 0.0	75	DT= 0.50000E-02
76	TN= 5.0000	77	KT1= 3040.0	78	KT2= 3040.0	79	KT3= 3040.0	80	KT4= 3040.0
81	RPS1= 0.0	82	RPS2= 0.0	83	RPS3= 0.0	84	RPS4= 0.0	85	B1=-0.23600E-03
86	B2= 0.0	87	B3= 1.3200	88	B4= 0.29700E-07	89	D1DT= 0.0	90	D2DT= 0.0
91	D3DT= 0.0	92	DELF= 0.0	93	DELR= 0.0	94	DEL3= 0.0	95	PHDT= 0.0
96	PHIR= 0.0	97	DFW1= 0.0	98	DFW2= 0.0	99	U1PR= 0.0	100	U2PR= 0.0
101	U3PR= 0.0	102	U4PR= 0.0	103	S1PR= 0.0	104	S2PR= 0.0	105	S3PR= 0.0
106	S4PR= 0.0	107	PPRT= 1.0000	108	FREQ= 0.40000	109	= 0.0	110	TQMX= 4428.0
111	KTQ= 738.00	112	VC= 0.0	113	MTSW= 1.0000	114	DSWM= 62.000	115	TST= 1.0000
116	DSLP= 0.50000	117	CGAM= 3.0000	118	CS= 3.0000	119	TQR= 0.0	120	TQF= 0.0
121	PFL= 300.00	122	TTD= 0.0	123	DSW1= 0.0	124	= 0.0	125	ISW5= 0.0
126	SW15= 0.0	127	= 0.0	128	VTPS= 3.0000	129	VHTP= 0.0	130	AMCR= 0.78000E-01
131	ESP= 0.27900	132	KSL1= 0.15000E 06	133	KSL2= 0.15000E 06	134	AA1= 8.0200	135	AA2= 8.0200
136	CCR= 11.000	137	CFCR= 120.00	138	AP= 7.5000	139	EP1= 0.90000E-02	140	EP2=-0.90000E-02
141	AERO= 0.0	142	VYW = 0.0	143	OMXW= 0.0	144	OMZW= 0.0	145	RHOA= 0.11470E-06
146	CYP = 0.0	147	CYR = 0.0	148	CZAL= 0.0	149	CZQ = 0.0	150	CLP = 0.0
151	CLR = 0.0	152	CMAL= 0.0	153	CMQ = 0.0	154	CNP = 0.0	155	CNR = 0.0
156	SF = 9100.0	157	VLEN= 294.00	158	REWV= 1094.0	159	= 0.0	160	= 0.0
161	= 0.0	162	= 0.0	163	= 0.0	164	= 0.0	165	= 0.0
166	= 0.0	167	= 0.0	168	= 0.0	169	SNT= 73.000	170	SNS0= 75.000
171	SNS1= 75.000	172	SNSW= 2.0000	173	DIST= 0.0	174	PL = 0.0	175	TSCP= 0.25000
176	SCSW= 1.0000	177	= 0.0	178	= 0.0	179	= 0.0	180	= 0.0
181	= 0.0	182	SI1= 0.20000	183	SI2= 0.20000	184	SI3= 0.20000	185	SI4= 0.20000
186	SARF= 118.15	187	SALF= 118.15	188	SARR= 73.500	189	SALR= 73.500	190	= 0.0
191	= 0.0	192	MTQB= 1.0000	193	DCSW= 0.0	194	LDF= 0.0	195	LDRF= 0.0
196	EK1=-0.18000E-02	197	EK2= 0.18000E-02	198	BMPL= 0.0	199	BMPS= 0.0	200	BMPH= 1.5000
201	XB= 0.0	202	APF1= 1.0400	203	APF2=-0.75800E-04	204	APR1= 1.0400	205	APR2=-0.75800E-04
206	MUSF= 0.72000	207	MUSR= 0.72000	208	BCON= 0.30000E-01	209	FCSW= 0.0	210	S1F = 0.0
211	S1R = 0.0	212	KLR = 0.0	213	KOTF= 0.0	214	KOTR= 0.0	215	= 0.0
216	= 0.0	217	= 0.0	218	= 0.0	219	FEE1= 0.34900E-01	220	FEE2=-0.34900E-01
221	THE1= 0.69800E-01	222	THE2= 0.69800E-01	223	ALMC= 0.0	224	= 0.0	225	= 0.0
226	= 0.0	227	= 0.0	228	= 0.0	229	= 0.0	230	= 0.0
231	H1= 600.00	232	H2= 600.00	233	LAMD= 0.0	234	= 0.0	235	= 0.0
236	PS01= 0.0	237	PS02= 0.0	238	BR1= 1.1300	239	BR2= 1.1300	240	BR3= 1.0000
241	BR4= 1.0000	242	KCF=-0.20000E-04	243	KCR=-0.20000E-04	244	KSR= 0.15000E-05	245	RB1=-0.23600E-03
246	RB2= 0.0	247	RB3= 1.3200	248	RB4= 0.29700E-07	249	AFK1=-0.15700E-02	250	AFK2= 0.14800E-02
251	AFK3= 1.6080	252	ARK1=-0.15700E-02	253	ARK2= 0.14800E-02	254	ARK3= 1.6080	255	OFC0= 0.0
256	OFC1=-0.62400E-03	257	OFC2= 0.24000E-02	258	OFC3= -9.1320	259	ORC0= 0.0	260	ORC1=-0.62400E-03
261	ORC2= 0.24000E-02	262	ORC3= -9.1320	263	CP0F= 0.0	264	CP1F= 0.0	265	CP2F= 0.0
266	CP0R= 0.0	267	CP1R= 0.0	268	CP2R= 0.0	269	CR0F= 0.0	270	CR1F= 0.0
271	CR2F= 0.0	272	CR0R= 0.0	273	CR1R= 0.0	274	CR2R= 0.0	275	STSW= 0.0
276	MMSW= 0.0	277	BMPN= 0.0	278	TQB0= 0.0	279	TQB1= 0.0	280	= 0.0
281	= 0.0	282	= 0.0	283	= 0.0	284	HFC= 0.0	285	HRC= 0.0
286	DRSW= 0.0	287	AXLE= 0.0	288	DUAL= 1.0000	289	TIRE= 6.0000	290	ROT = 1.0000
291	RA0 = 635.20	292	RA1 = 11.980	293	RA2 = 5447.9	294	RA3 = 1.8900	295	RA4 = 6306.2

G-5. APL Operational Vehicle Data Decks

Vehicle	Suspension	
	Front	Rear
VW Campmobile (73)	I	I
VW Super Beetle (71)	I	I
Chevrolet NOVA (74)	I	S
Chevrolet NOVA (75)	I	S
Ford Torino (75)	I	S
Ford Mustang (71)	I	S
Dodge Coronet (71)	I	S
Pontiac Trans Am (71)	I	S
Chevrolet Brookwood Station Wagon (71)	I	S
Chevrolet Caprice Station Wagon (73)	I	S
F-250 Pickup with 11 Foot Open Road Camper (74)	I	S
Ford Econoline Van (69)	I	S
Ford F-250 Pickup (74)	I	S
Plymouth Fury (77)	I	S
Ford Pinto (76/77)	I	S
Chevrolet Monte Carlo (76)	I	S
Ford LTD (76)	I	S
AMC Pacer (77)	I	S
Mercury Bobcat Wagon	I	S
Chevrolet NOVA (76)	I	S
Open Road Motor Home Type C (74) (Dodge MB 300/127" WB)	I	S,D
Jeep Wagoneer (74)	S	S
Winnebago Motor Home Type A (74) (Dodge Rm 400/158.5" WB)	S	S,D
White Road Boss (4x2) Heavy Truck (74)	S	S,D
GMC-PD 4107 Intercity Bus (66)	S	S,D

I = Independent
S = Solid
D = Dual tires, one rear axle

Appendix H

IMPROVED HYBRID COMPUTER VEHICLE HANDLING SIMULATION IMPLEMENTATION DOCUMENTATION

H-1. DSL/91 Digital Static Check Program

Presented here is the computer listing of the DSL/91 digital static check program.

```
              INPUT FOR DSL/91 TRANSLATOR (VERSION 2)

TITLE   NEW VEHICLE PROB = 91
PARAM IAXLE = 0
PARAM AKT1=1250.,AKT2=1250.,AKT3=1250.,AKT4=1250.
PARAM RF=-24200.,RR=-69000.
PARAM TSF=32.25,TSR=43.25,TF=57.3,TR=57.5
PARAM HFC=.63,HRC=2.22,ZF=16.01,ZR=15.8
PARAM CFP=73.,CRP=60.,A=49.61,B=60.39
PARAM AMS=7.3   ,AMUF=.937,AMUR=.888
PARAM AKF=700.,AKR3=210.,AKR4=210.
PARAM IF=498., IR=459.,SCALE=2000.
PARAM AIX=7330.,AIY=25740.,AIZ=29700.,AIXZ=250.
PARAM F3F1=80.,F3F2=23.,F3R3=152.2,F3R4=49.
PARAM CMCN1F=0.0,CMCN1R=0.0
PARAM GEE=386.4
PARAM BETA=.25
PARAM DTIN=.005
INCON UO=704.,  VO=13.,  WO=5.
INCON PO=.04,  QO= .037, RO=.02
INCON THEO=-.00209, PHIO=-.003, PSIO=.002
INCON DEL1=.383,  DEL1DT=10.
INCON DEL2=0.866,  DEL2DT=15.
INCON DEL3=.200,DEL4=.300,DEL3DT=5.,DEL4DT=7.
INCON DELF=.8,DELFDT=25.,PHIF=.02,PHIFD=.6
INCON SNPHIF=-163.
INCON DELRDT=20.,  PHIRD=.55
INCON DELR=.6,  PHIR=.01895
INCON ANTI1=874.,ANTI2=874.,ANTI3=692.,ANTI4=692.
INCON FYU1=-33.45,FYU2=33.45,FYU3=-10.,FYU4=10.
INCON SFXU=-20.0,SFYL=30.0,SFZS=-1090.
INCON FZU1=-972.,FZU2=-972.,FZU3=-844.,FZU4=-844.
```

```
INCON SNPHIU=-111.,SNTHEL=-274.,SNPSIU=-755.,SNPHIR=-163.
INCON RPS1 =57.01,   RPS2=57.01,   RPS3=56.55,   RPS4=56.55
CONTRL TSTART=0.,FINTIM=.002,DELT=.001
DYNAMIC
      P = PO
      Q = QO
      R = RO
      U = UO
      V = VO
      W = WO
      THE = THEO
      PHI = PHIO
      PSI = PSIO
      COSTHE=COS(THEO)
      SINPHI=SIN(PHIO)
      SINTHE=SIN(THEO)
      COSPHI=COS(PHIO)
      P2=PO*PO
      Q2=QO*QO
      R2=RO*RO
      QR=QO*RO
      PR=PO*RO
      WP=PO*WO
      VR=VO*RO
      WQ=WO*QO
      UR=RO*UO
      UQ=UO*QO
      PQ=PO*QO
      VP=VO*PO
      TFO2 = TF/2.
      TRO2 = TR/2.
      TSFO2 = TSF/2.
      TSRO2 = TSR/2.
      G=GEE
      SM=AMS+AMUF+AMUR
      GAM1 = A*AMUF - B*AMUR
      IF(IAXLE.NE.0) GO TO 100
      GAM2 = AMUF*(ZF+DELF)+AMUR*(ZR+DELR)
      GAM3 = GAM2
      GAM4 = 0.0
      GAM5 = AMUF*A**2+AMUR*B**2
      GAM6 = 2.*AMUF*DELFDT+2.*AMUR*DELRDT
      GAM7 = 2.*AMUF*DELFDT*(ZF+DELF)+2.*AMUR*DELRDT*(ZR+DELR)
      GAM8 = 0.0
      GAM9 = 2.*AMUF*A*DELFDT-2.*AMUR*B*DELRDT
      AIXP = AMUF*(ZF+DELF)**2+AMUR*(ZR+DELR)**2
      AIYP = AIXP
      AIZP = AMUF*A**2+AMUR*B**2+IF+IR
      AIXZP = AMUF*A*(ZF+DELF)-AMUR*B*(ZR+DELR)
      GO TO 1000
```

```
100   IF(IAXLE.NE.1) GO TO 200
      GAM2 = AMUF*(ZF + (DEL1+DEL2)/2.0) + AMUR*(ZR+DELR)
      GAM3 = GAM2
      GAM4 = AMUF*TFO2/2.0*(DEL1-DEL2)
      GAM5 = AMUF*(A**2-TFO2**2) + AMUR*B**2
      GAM6 = AMUF*(DEL1DT+DEL2DT) + 2.*AMUR*DELRDT
      GAM7 = AMUF* (ZF*(DEL1DT+DEL2DT) + DEL1*DEL1DT+DEL2*DEL2DT)  ...
         + 2.0*AMUR*(ZR+DELR)*DELRDT
      GAM8 = AMUF*TFO2*(DEL1DT-DEL2DT)
      GAM9 = AMUF*A*(DEL1DT+DEL2DT) - 2.*AMUR*B*DELRDT
      AIXP = AMUF/2.0*((ZF+DEL1)**2 + (ZF+DEL2)**2) + AMUR*(ZR+DELR)**2
      AIYP = AIXP
      AIZP = AMUF*(A**2+TFO2**2) + AMUR*B**2 + IR
      AIXZP = AMUF*A/2.0*((ZF+DEL1) + (ZF+DEL2)) - AMUR*B*(ZR+DELR)
      GO TO 1000
200   CONTINUE
      GAM2 = AMUF*(ZF+(DEL1+DEL2)/2.)+AMUR*(ZR+(DEL3+DEL4)/2.)
      GAM3 = GAM2
      GAM4 = AMUF*TFO2/2.*(DEL1-DEL2)+AMUR*TRO2/2.*(DEL3-DEL4)
      GAM5 = AMUF*(A*A-TFO2**2)+AMUR*(B*B-TRO2**2)
      GAM6 = AMUF*(DEL1DT+DEL2DT)+AMUR*(DEL3DT+DEL4DT)
      GAM7 = AMUF*(ZF*(DEL1DT+DEL2DT)+DEL1*DEL1DT+DEL2*DEL2DT)  ...
             + AMUR*(ZR*(DEL3DT+DEL4DT)+DEL3*DEL3DT+DEL4*DEL4DT)
      GAM8 = AMUF*TFO2*(DEL1DT-DEL2DT)+AMUR*TRO2*(DEL3DT-DEL4DT)
      GAM9 = AMUF*A*(DEL1DT+DEL2DT)-AMUR*B*(DEL3DT+DEL4DT)
      AIXP = AMUF/2.*((ZF+DEL1)**2+(ZF+DEL2)**2)  ...
           + AMUR/2.*((ZR+DEL3)**2 +(ZR+DEL4)**2)
      AIYP = AIXP
      AIZP = AMUF*(A*A+TFO2**2)+AMUR*(B*B+TRO2**2)
      AIXZP = AMUF*A/2.*((ZF+DEL1)+(ZF+DEL2))   ...
            - AMUR*B/2.*((ZR+DEL3)+(ZR+DEL4))
1000  CONTINUE
      AIXXP = AIX + AIXP
      AIYYP = AIY + AIYP
      AIZZP = AIZ+AIZP
*     UNSCALED  DAC  VALUES  FOR  SYSTEM  EQUATIONS
      DAC00 = GAM2/SM
      DAC01 = GAM1/SM
      DAC02 = GAM1/SM
      DAC03 = GAM2/SM
      DAC04 = GAM3/AIXXP
      DAC05 = (AIXZ+AIXZP)/AIXXP
      DAC06 = GAM7/AIXXP
      DAC07 = GAM4/AIXXP
      DAC08 = 1.0/AIXXP
      DAC09 = GAM2/AIYYP
      DAC10 = AIXZ/AIYYP
      DAC11 = AIXZP/AIYYP
      DAC12 = GAM7/AIYYP
```

```
      DAC13 = GAM4/AIYYP
      DAC14 = 1.0/AIYYP
      DAC15 = (AIXZ+AIXZP)/AIZZP
      DAC16 = GAM1/AIZZP
      DAC17 = GAM4/AIZZP
      DAC20 = 55.71
      DAC21 = 55.71
      DAC22 = 64.76
      DAC23 = 64.76
      DAC26 = 1./SM*(-GAM6*Q+SFXU)
      DAC27 = 1./SM*(GAM6*P+SFYU)
      DAC28 = 1./AMS*SFZS
      DAC29 = ((AIY-AIZ+AIXP)*QR+SNPHIU)/AIXXP
      DAC30 = ((AIZ-AIX-AIYP)*PR+SNTHEU)/AIYYP
      DAC31 = ((AIX-AIY-GAM5)*PQ+GAM8*Q+GAM9*P+SNPSIU)/AIZZP
      DAC32 = 3692.0
      DAC33 = 3692.0
      DAC34 = 3151.0
      DAC35 = 3151.0
      DAC37 = ANTI1
      DAC38 = ANTI2
      DAC39 = ANTI3
      DAC40 = ANTI4
      IF(IAXLE.NE.0) GO TO 300
      DAC28 = SFZS/10.939
      DAC41 = 1.0/AMLF*(FZU1+FZU2)
       DAC42 = 1.0/IF*SNPHIF
      DAC43 = 1.0/AMLR*(FZU3+FZU4)
      DAC44 = 1.0/IR*SNPHIR
      GO TO 2000
300   IF(IAXLE.NE.1) GO TO 400
      DAC41 = 2.0/AMLF*(FZU1-FYU1*TAN(2.0*HFC/TF))
      DAC42 = 2.0/AMLF*(FZU2-FYU2*TAN(2.*HFC/TF))
      DAC43 = 1.0/AMUR*(FZU3+FZU4)
      DAC44 = 1.0/IR*SNPHIR
      GO TO 2000
400   CONTINUE
      DAC41 = 2.0/AMLF*(FZU1-FYU1*TAN(2.0*HFC/TF))
      DAC42 = 2.0/AMLF*(FZU2-FYU2*TAN(2.*HFC/TF))
      DAC30 = .2702
      DAC43 = 2./AMUR*(FZU3-FYU3*TAN(2.*HRC/TR))
      DAC44 = 2./AMUR*(FZU4+FYU4*TAN(2.*HRC/TR))
2000  CONTINUE
      IF(IAXLE.NE.0) GO TO 500
      ZET1 = TSFO2*PHIF+DELF
      ZET2 = -TSFO2*PHIF+DELF
      ZET3 = TSRO2*PHIR + DELR
      ZET4 =-TSRO2*PHIR + DELR
      ZET1DT = TSFO2*PHIFD+DELFDT
      ZET2DT= -TSFO2*PHIFD+DELFDT
```

```
      ZET3DT = TSRO2*PHIRD  + DELRDT
      ZET4DT =-TSRO2*PHIRD  + DELRDT
      F1F1 = SIGN(1.,ZET1DT)*CFP
      F1F2 = SIGN(1.,ZET2DT)*CFP
      F1R3 = SIGN(1.,ZET3DT)*CRP
      F1R4 = SIGN(1.,ZET4DT)*CRP
      F2F1 = AKF*ZET1
      F2F2 = AKF*ZET2
      F2R3 = AKR3*ZET3
      F2R4 = AKR4*ZET4
      S1 = -F3F1-F2F1-(RF/TSF)*PHIF-F1F1+DAC37
      S2 = -F3F2-F2F2-(RF/TSF)*PHIF-F1F2+DAC38
      S3 = -F3R3-F2R3-(RR/TSR)*PHIR - F1R3 + DAC39
      S4 = -F3R4-F2R4-(RR/TSR)*PHIR - F1R4 + DAC40
      GO TO 5000
500   IF(IAXLE.NE.1) GO TO 600
      ZET1 = DEL1
      ZET2 = DEL2
      ZET3 = TSRO2*PHIR  + DELR
      ZET4 =-TSRO2*PHIR  + DELR
      ZET1DT = DEL1DT
      ZET2DT = DEL2DT
      ZET3DT = TSRO2*PHIRD  + DELRDT
      ZET4DT =-TSRO2*PHIRD  + DELRDT
      F1F1 = SIGN(1.,ZET1DT)*CFP
      F1F2 = SIGN(1.,ZET2DT)*CFP
      F1R3 = SIGN(1.,ZET3DT)*CRP
      F1R4 = SIGN(1.,ZET4DT)*CRP
      F2F1 = AKF*ZET1
      F2F2 = AKF*ZET2
      F2R3 = AKR3*ZET3
      F2R4 = AKR4*ZET4
      AUXRL1 = (DEL2-DEL1)*RF/TF**2
      AUXRL2 = -AUXRL1
      S1 = AUXRL1-F3F1-F2F1-F1F1+DAC37
      S2 = AUXRL2-F3F2-F2F2-F1F2+DAC38
      S3 = -F3R3-F2R3-(RR/TSR)*PHIR - F1R3 + DAC39
      S4 = -F3R4-F2R4-(RR/TSR)*PHIR - F1R4 + DAC40
      GO TO 5000
600   CONTINUE
      ZET1 = DEL1
      ZET2 = DEL2
      ZET3 = DEL3
      ZET4 = DEL4
      ZET1DT = DEL1DT
      ZET2DT = DEL2DT
      ZET3DT = DEL3DT
      ZET4DT = DEL4DT
      F1F1 = SIGN(1.,ZET1DT)*CFP
      F1F2 = SIGN(1.,ZET2DT)*CFP
```

```
      F1R3 = SIGN(1.,ZET3DT)*CRP
      F1R4 = SIGN(1.,ZET4DT)*CRP
      F2F1 = AKF*ZET1
      F2F2 = AKF*ZET2
      F2R3 = AKR3*ZET3
      F2R4 = AKR4*ZET4
      AUXRL1 = (DEL2-DEL1)*RF/TF**2
      AUXRL2 = -AUXRL1
      AUXRL3 = (DEL4-DEL3)*RR/TR**2
      AUXRL4 = -AUXRL3
      S1 = AUXRL1-F3F1-F2F1-F1F1+DAC37
      S2 = AUXRL2-F3F2-F2F2-F1F2+DAC38
      S3 = AUXRL3-F3R3-F2R3-F1R3+DAC39
      S4 = AUXRL4-F3R4-F2R4-F1R4+DAC40
5000  CONTINUE
      SUMSI = S1+S2+ S3+S4
*     NOTE
*          ACCELERATION TERMS HAVE BEEN ELIMINATED
*          FROM R.H.S OF UDT,VDT,PDT,QDT AND RDT
*          EQUATIONS. ALSO FROM AMPLIFIERS A066 AND
*          A106 DESCRIPTIONS.
      UDT        = VR - WQ -GEE*SINTHE -DAC00 *(PR+0.0) + DAC01  ...
           * (Q2+R2) + DAC26
      VDT        = WP - UR +GEE*COSTHE*SINPHI -DAC02 *(PQ+0.0) ...
                 - DAC03 *(QR-0.0) + DAC27
      WDT        = UQ - VP +GEE*COSTHE*COSPHI + DAC28  - SUMSI/AMS
      QDT        = DAC09 *(VR-0.0-WQ-GEE*SINTHE) + (R2-P2)*DAC10  ...
                 + (Q2+R2)*DAC11  - (PQ-0.0)*DAC13  + DAC30  + ...
      DAC14 *(A*(S1+S2) - B*(S3+S4)) - Q*DAC12
      RDT       = DAC16 *(WP-0.0-UR +GEE*COSTHE*SINPHI) + ...
                 DAC17 *(PR+0.0) - DAC15 *(QR-0.0) + DAC31
*
      PSIDT      = (R*COSPHI + Q*SINPHI)/COSTHE
      PHIDT      = P + PSIDT*SINTHE
      THEDT      = Q*COSPHI - R*SINPHI
      IF(IAXLE.NE.0) GO TO 700
      PDT        = DAC04 *(0.0+UR-WP-GEE*COSTHE*SINPHI) + ...
                 DAC05 *(PQ+0.0) - DAC07  * (P2+R2) +DAC29 +  ...
       DAC08*(TSFO2*(S2-S1) + TSRO2*(S4-S3)) -P*DAC06
      DELFDD = UQ-VP+GEE*COSTHE*COSPHI-A*PR+(ZF+DELF)*(P2+Q2)  ...
              -WDT+A*QDT+DAC41+(S1+S2)/AMUF   ...
              -(AKT1+AKT2)/AMUF*BETA*(.008+.5*DTIN/BETA)*DELFDT
      PHIFDD = -(QR+PDT)+PHIF*(Q2-R2)+DAC42+TSFO2*(S1-S2)/IF  ...
      -(((AKT1+AKT2)*TFO2*TFO2*BETA*(.008+.5*DTIN/BETA))/IF)*PHIFD
      DELRDD   = UQ -VP + GEE*COSTHE*COSPHI + B*PR + (ZR+DELR)* ...
                 (P2+Q2) - WDT -B*QDT + DAC43  + (S3+S4)/AMUR   ...
   -  (AKT3+AKT4)/AMUR*BETA*     (.008+.5*DTIN/BETA)*DELRDT
      PHIRDD   = -(QR+PDT) + PHIR*(Q2-R2) + DAC44  + TSRO2*(S3-S4)/IR...
   -(((AKT3+AKT4)*TRO2*TRO2*BETA*     (.008+.5*DTIN/BETA))/IR)*PHIRD
      GO TO 7000
```

```
70C   IF(IAXLE.NE.1) GO TO 800
      PDT        = DAC04 *(0.0+UR-WP-GEE*COSTHE*SINPHI) + ...
                   DAC05 *(PQ+0.0) - DAC07  * (P2+R2) +DAC29 +  ...
       DAC08 *(TFO2*(S2-S1) + TSRO2*(S4-S3)) -P*DAC06
      DELPDD     = UQ - VP + GEE*COSTHE*COSPHI -A*PR -WDT + A*QDT
      DEL1DD     = DELPDD + (ZF+DEL1)*(P2+Q2) - TFO2*(PDT+QR) + DAC41 +...
                   2.*S1/AMUF  ...
    - (2.*AKT1/AMUF)*BETA*     (.008+.5*DTIN/BETA)*DEL1DT
      DEL2DD     = DELPDD + (ZF+DEL2)*(P2+Q2) + TFO2*(PDT+QR) + ...
                   DAC42  + 2.*S2/AMUF ...
    - (2.*AKT2/AMUF)*BETA*     (.008+.5*DTIN/BETA)*DEL2DT
      DELRDD     = UQ -VP + GEE*COSTHE*COSPHI + B*PR + (ZR+DELR)* ...
                   (P2+Q2) - WDT -B*QDT + DAC43  + (S3+S4)/AMUR   ...
   -  (AKT3+AKT4)/AMUR*BETA*     (.008+.5*DTIN/BETA)*DELRDT
      PHIRDD     = -(QR+PDT) + PHIR*(Q2-R2) + DAC44  + TSRO2*(S3-S4)/IR...
   -(((AKT3+AKT4)*TRO2*TRO2*BETA*     (.008+.5*DTIN/BETA))/IR)*PHIRD
      GO TO 7000
800   CONTINUE
      PDT        = DAC04 *(0.0+UR-WP-GEE*COSTHE*SINPHI) + ...
                   DAC05 *(PQ+0.0) - DAC07  * (P2+R2) +DAC29 +  ...
       DAC08 *(TFO2*(S2-S1) + TRO2 *(S4-S3)) -P*DAC06
      DELPDD     = UQ - VP + GEE*COSTHE*COSPHI -A*PR -WDT + A*QDT
      DEL1DD     = DELPDD + (ZF+DEL1)*(P2+Q2) - TFO2*(PDT+QR) + DAC41 +...
                   2.*S1/AMUF  ...
    - (2.*AKT1/AMUF)*BETA*     (.008+.5*DTIN/BETA)*DEL1DT
      DEL2DD     = DELPDD + (ZF+DEL2)*(P2+Q2) + TFO2*(PDT+QR) + ...
                   DAC42  + 2.*S2/AMUF ...
    - (2.*AKT2/AMUF)*BETA*     (.008+.5*DTIN/BETA)*DEL2DT
      DELPDR = UQ-VP+GEE*COSTHE*COSPHI+B*PR-WDT-B*QDT
      DEL3DD = DELPDR+(ZR+DEL3)*(P2+Q2)-(PDT+QR)*TRO2+DAC43  ...
                   + 2.*S3/AMUR  ...
   -  (2.*AKT3/AMUR)*BETA*     (.008+.5*DTIN/BETA)*DEL3DT
      DEL4DD = DELPDR+(ZR+DEL4)*(P2+Q2)+(PDT+QR)*TRO2+DAC44  ...
                   + 2.*S4/AMUR  ...
   -  (2.*AKT4/AMUR)*BETA*     (.008+.5*DTIN/BETA)*DEL4DT
7000  CONTINUE
      RPS1DT = -OMCN1F*RPS2DD + DAC32  - DAC22 *RPS1
      RPS2DT = -OMCN1F*RPS1DD + DAC33  - DAC23 *RPS2
      RPS3DT = -OMCN1R*RPS4DD + DAC34  - DAC20 *RPS3
      RPS4DT = -OMCN1R*RPS3DD + DAC35  - DAC21 *RPS4
*
*     680 IC PCTS
      P000=QC/.8
      P005=UC/1200.
      P020= -4.*THEC
      P023=PSIC/4.
      P075=DEL2/10.
      P086=DELR/10.
      P101=RPS1/100.
      P110=RPS3/100.
```

```
*      LDT AND VDT DECCUPLING PCTS
       P111=0.0
       P114=0.0
*
*      REAR WHEELS DIFFERENTIAL DECOUPLING POTS
       P050=0.0
       P119=0.0
*      HAND SET PCTS
       Q002=DEL2DT/10C.
       Q004=PHIRD/10.
       QC07=PHIR/1.
       QC09=DEL1/10.
       Q012=RC/4.
       Q014=VC/1000.
       Q017=PC/2.
       QC19=WC/100.
       Q022=DEL1DT/10C.
       Q024=DELRDT/100.
       Q027 =-1.5*PHIC
       IF(IAXLE.NE.0) GO TO 900
       PC75 = PHIF/1.
       Q002 = PHIFD/1C.
       Q009 = DELF/10.
       Q022 = DELFDT/100.
       GC TO 9000
900    IF(IAXLE.NE.2) GO TO 9000
       P086 = DEL3/10.
       Q004 = DEL4DT/100.
       Q007 = DEL4/10.
       Q024 = DEL3DT/100.
9000   CONTINUE
*     680 AMPS
*      IC AMPS
       A000=QC/.8
       A005=UC/1200.
       A007=PC/2.
       A010=VC/1000.
       A012=RC/4.
       A015=WC/100.
       A020= 4. * THEC
       AC25= -1.5* PHIC
       A027=PSIC/4.
       A040= PHIR/1.
       A095=-PHIRD/10.
       A050=-DEL1DT/100.
       AC55=DEL1/10.
       A070=-DEL2DT/1C0.
       A075=DEL2/10.
       A080=-DELRDT/1CC.
       A085=DELR/10.
```

```
      A100=-RPS1/100.
      A105=-RPS2/100.
      A110=-RPS3/100.
      A115=-RPS4/100.
*
      A001= (QC*SINPHI+RC*COSPHI)/2.
      A002=-LDT/800.
      A004= -DEL1/10.
      A008=SINPHI*COSTHE
      A009= -((DEL2-DEL1)/10.)
      A011=-VDT/1500.
      A014=DEL2DT/100.
      A016=-S1/SCALE
      A017= -(PHIR/1.-DELR/10.)
      A018=VC*RO/4000.
      A019 = 0.0
      A021=-S2/SCALE
      A022=RPS4DT/10000.
      A023=VP/2000.
      A024=-PHIR/1.
      A026=-S3/SCALE
      A028=PHIR*(Q2-R2)/4.
      A029 = (DEL2-DEL1)*(RF/(TF*TF))/10000.
      A030 = (S1+S2)/SCALE*A/100. - (S3+S4)/SCALE*B/100.
      A031=-F2F2/10000.
      A032=-DEL2/10.
      A034 = S1/SCALE
      A035=-WDT/200.
      A036=-F2R3/10000.
      A037 = S2/SCALE
      A039=ZET1DT/100.
      A041 = ((S2-S1)*TFC2+(S4-S3)*TSRO2)/(100.*SCALE)
      A042=ZET2DT/100.
      A043=-LR/4800.
      A044=PHIRD/10.
      A045=-F2R4/10000.
      A046 = (UQ-VP+G*COSTHE*COSPHI)/1000.
      A047=ZET4DT/100.
      A049=ZET3DT/100.
      A051=-S4/SCALE
      A052=-DELR/10.
      A053 = -LQ/960.
      A056=RPS1DT/10000.
      A057=UDT/800.
      A058 = (DELR*(P2+Q2))/40.
      A059 = -VO*RO/4000.
      A060=RPS2DT/10000.
      A061 = -(SUMSI/AMS)/1000.
      A062= SINPHI
      A063=-WQ/80.
```

```
*       A064 USE AS HG AMP IN SINPHI CKT
        A066 = (LR-WP-G*COSTHE*SINPHI)/1000.
        A067=COSTHE
        A068=-WP/200.
        A069 = TFO2*(PDT+QR)*BETA/1000.
        A071 = -(A*(S1+S2))/(100.*SCALE)
        A072=COSPHI
*       A074 USE AS HG AMP   IN COSPHI CKT
        A076=RPS3DT/10000.
        A077=-SINTHE
        A078=-COSTHE*COSPHI
        A081=-PDT/12.
        A082 = S4/SCALE
        A083 = -(QO*SINPHI)/0.8
        A084=SINTHE
        A086 = (B*(S3+S4))/(100.*SCALE)
        A087 = WQ/80.
        A088= -(RO*COSPHI)/4.
*       A089 USE AS HG AMP IN COSTHE CKT
        A090=-F2F1/10000.
        A091 = (TSRO2*(S3-S4))/(100.*SCALE)
        A092=WP/1000.
        A093 = (QO*COSPHI)/0.8
        A096= -4.*THEDT*BETA
        A098= -(RO*SINPHI)/4.
        A101=-QDT/2.
        A103=-PSIDT/2.
        A104 = S3/SCALE
        A106 = (VR-WQ-G*SINTHE)/1000.
        A108 = (PSIDT*SINTHE)/2.
        A109=WDT/200.
        A111 = (TFO2*(S1-S2))/(100.*SCALE)
        A112= -(PR-QDT)/8.
        A113 = ((P2+Q2)*DEL1)/40.
        A114 = -(A*(PR-QDT)+WDT)/200.
        A116=-RDT /20.
*       A117=0.0 FOR SOLID REAR AXLE
        A117=0.0
        A118 = ((P2+Q2)*DEL2)/40.
        A119 = (B*(PR-QDT)-WDT)/200.
        D000=-QDT /.8*BETA
        D005=-UDT/1200.*BETA
        D007=-PDT *BETA/2.
        D010=-VDT/1000.*BETA
        D012=-RDT *BETA/4.
        D015= -WDT*BETA/100.
        D020= -4.*THEDT*BETA
        D025=1.5*PHIDT*BETA
        D027= -PSIDT*BETA/4.
        D040=-PHIRD*BETA/1.
```

```
      D050=DEL1DD/1000.*BETA
      D055=-DEL1DT/10.*BETA
      D070=DEL2DD/1000.*BETA
      D075=-DEL2DT/10.*BETA
      D080=DELRDD/1000.*BETA
      D085=-DELRDT/10.*BETA
      D095=PHIRDD/10.*BETA
      D100=RPS1DT/1000.*BETA
      D105=RPS2DT/1000.*BETA
      D110=RPS3DT/1000.*BETA
      D115=RPS4DT/1000.*BETA
*     SCALED  DAC'S
      DA00 = -DAC00/50.
      DA01 =  DAC01/100.
      DA02 = -DAC02/50.
      DA03 = -DAC03/625.
      DA04 =  DAC04/.04
      DA05 =  DAC05/.4
      DA06 = -DAC06/2.
      DA07 = -DAC07/1.
      DA08=DAC08*SCALE/.8
      DA09 =  DAC09/.003
      DA10 =  DAC10/.25
      DA11 =  DAC11/.25
      DA12 = -DAC12/1.25
      DA13 = -DAC13/.1
      DA14=DAC14*SCALE/.2
      DA15 = -DAC15/1.25
      DA16 = -DAC16/.01
      DA17 =  DAC17/1.25
      DA20 =-DAC20/1000.
      DA21 =-DAC21/1000.
      DA22 =-DAC22/1000.
      DA23 =-DAC23/1000.
      DA26 = DAC26/400.
      DA27 = DAC27/1000.
      DA28 = DAC28/1000.
      DA29 = DAC29/28.
      DA30 = DAC30/10.
      DA31 = DAC31/10.
      DA32 = -DAC32/20000.
      DA33 = -DAC33/20000.
      DA34 = -DAC34/20000.
      DA35 = -DAC35/20000.
      DA37 = DAC37/10000.
      DA38 = DAC38/10000.
      DA39 = DAC39/10000.
      DA40 = DAC40/10000.
      DA41 = DAC41*BETA/10000.
      DA42 = DAC42*BETA/10000.
```

```
      DA43 = CAC43*BETA/10000.
      DA44 = CAC44*BETA/100.0
      IF(IAXLE.NE.0) GO TO 910
      A004 = -CELF/1C.
      A009 = -(PHIF/1. -CELF/1C.)
      A014 = PHIFD/10.
      A029 = 0.0
      A032 = -PHIF/1.
      A041 = ((S2-S1)*TSFO2+(S4-S3)*TSRO2)/(100.*SCALE)
      A050 = -CELFDT/100.
      A055 = DELF/10.
      A069 = 0.0
      A070 = -PHIFD/10.
      AC75 = PHIF/1.
      A111 = (TSFO2*(S1-S2))/(10C.*SCALE)
      A113 = ((P2+Q2)*DELF)/40.
      A118 = ((P2+Q2)*PHIF)/4.
      C050 =  CELFDD/100C.*BETA
      D055 = -CELFDT/10.*BETA
      C070 = PHIFDD/10.*BETA
      C075 = -PHIFD*BETA
      CA42 = DAC42*BETA/100.
      GC TO 10000
 91C  IF(IAXLE.NE.2) GOTC 10000
      A017 = -(DEL4-DEL3)/10.
      A019 = ALXRL3/1000.
      A024 = -CEL4/1C.
      A028 = DEL4*(P2+Q2)/40.
      A040 = DEL4/10.
      A041 = ((S2-S1)*TFC2+(S4-S3)*TRO2 )/(1CO.*SCALE)
      A044 = CEL4DT/100.
      A052 = -CEL3/1C.
      A058 = CEL3*(P2+Q2)/40.
      A080 = -CEL3DT/100.
      A085 = DEL3/10.
      A091 = (TRO2 *(S3-S4))/(100.*SCALE)
      A095 = -CEL4DT/100.
      A117 = (PDT+QR)*TRO2/1CCC.*BETA
      C040 = -CEL4DT/10.*BETA
      C080 = DEL3DD/1000.*BETA
      C085 = -CEL3DT/1C.*BETA
      D095 = DEL4DD/1000.*BETA
      CA44 = DAC44*BETA/1000C.
10000 CCNTINLE
*    68C TRUNKS
      T040=ZET1DT/100.
      T041=ZET2DT/10C.
      T042= (Q2-R2)/4.
      T043=ZET4DT/10C.
      T053=ZET3DT/10C.
```

```
      T054=P/2.
      T055=Q/.8
      T056=R/4.
      T057=-PDT/12.
      T058=-RDT/20.
      T059=-QDT/2.
      T070=(PR-QDT)/8.
      T071= PR/8.
      T072=(R2-P2)/4.
      T073=(P2+R2)/4.
      T074=(P2+Q2)/4.
      T075=(Q2+R2)/4.
      T076= PQ/10.
      T077=(PQ-0.0 )/10.
      T078= -(QR+PDT)/8.
      T079=(QR-0.0 )/8.
      T080=-F3F1/1000.
      T082=-F3R3/1000.
      T083=-F3R4/1000.
      T088=-F3F2/1000.
TERMINAL
      DUMMY=DEBUG(1.,0.)
END
PARAM IAXLE = 1
PARAM AKT1=1295.,AKT2=1295.,AKT3=1295.,AKT4=1295.
PARAM RF=151000.,RR=0.0
PARAM TSF=0.0,TSR=43.,TF=61.5,TR=61.
PARAM HFC=3.,HRC=2.5,ZF=9.35,ZR=9.35
PARAM CFP=36.,CRP=50.,A=48.,B=61.
PARAM AMS=8.13,AMUF=.484,AMUR=.789
PARAM AKF=100.2,AKR3=114.,AKR4=114.
PARAM IF=3.3,IR=600.,SCALE=2000.
PARAM AIX=2940.,AIY=14700.,AIZ=22500.,AIXZ=230.
PARAM F3F1=15.2,F3F2=22.5,F3R3=152.2,F3R4=48.6
INCON SFZS= -100.
END
PARAM IAXLE = 2
PARAM AKT1=746.,AKT2=746.,AKT3=956.,AKT4=956.
PARAM RR=28300.,TSR=50.,TF=53.8,TR=51.5
PARAM HFC=2.4,HRC=3.4,ZF=10.8,ZR=11.2
PARAM CFP=35.,CRP=40.,A=55.9,B=39.9
PARAM AMS=5.5,AMUF=0.36,AMUR=0.57
PARAM AKF=101.1,AKR3=115.,AKR4=115.
PARAM IR=800.,RF=93000.,SCALE=1000.
PARAM AIX=2060.,AIY=9927.,AIZ=9385.,AIXZ=0.0
PARAM F3R3=30.,F3R4=42.
INCON ANTI1=384.6,ANTI2=384.6,ANTI3=623.7,ANTI4=623.7,SFZS=-400.
END
STOP
```

```
          *** OSL/91  SIMULATION DATA ***                                                    78.163        12:26:47.33
     TITLE    NEW VEHICLE PROB = 91
     PARAM IAXLE = 0
     PARAM AKT1=1250.,AKT2=1250.,AKT3=1250.,AKT4=1250.
     PARAM RF=-24200.,RR=-69000.
     PARAM TSF=32.25.TSR=43.25,TF=57.3,TR=57.5
     PARAM HFC=.63,HRC=2.22,ZF=16.01,ZR=15.8
     PARAM CFP=73.,CRP=60.,A=49.61,B=60.39
     PARAM AMS=7.3    ,AMUF=.937,AMUR=.888
     PARAM AKF=700.,AKR3=210.,AKR4=210.
     PARAM IF=498.,IR=459.,SCALE=2000.
     PARAM AIX=7330.,AIY=25740.,AIZ=29700.,AIXZ=250.
     PARAM F3F1=80.,F3F2=23.,F3R3=152.2,F3R4=49.
     PARAM OMCNIF=0.0,OMCNIR=0.0
     PARAM GEE=386.4
     PARAM BETA=.25
     PARAM CTIN=.005
     INCON UO=704.,  VO=13.,  WO=5.
     INCON PO=.04,  QO= .037, RO=.02
     INCON THEO=-.00209, PHIO=-.003, PSIO=.002
     INCON DEL1=.383,  DEL1DT=10.
     INCON DEL2=0.866,  DEL2DT=15.
     INCON DEL3=.200,DEL4=.300,DEL3DT=5.,DEL4DT=7.
     INCON DELF=.8,DELFDT=25.,PHIF=.02,PHIFO=.6
     INCON SNPHIF=-163.
     INCON DELRDT=20.,  PHIRO=.55
     INCON DELR=.6,  PHIR=.01895
     INCON ANTI1=874.,ANTI2=874.,ANTI3=692.,ANTI4=692.
     INCON FYU1=-33.45,FYU2=33.45,FYU3=-10.,FYU4=10.
     INCON SFXU=-20.0,SFYU=30.0,SFZS=-1090.
     INCON FZU1=-972.,FZU2=-972.,FZU3=-844.,FZU4=-844.
     INCON SNPHIU=-111.,SNTHEU=-274.,SNPSIU=-755.,SNPHIR=-163.
     INCON RPS1 =57.01,  RPS2=57.01,  RPS3=56.55,  RPS4=56.55
     CONTRL TSTART=0.,FINTIM=.002,DELT=.001
     END

***OSL MESSAGE 20***   NO OUTPUT REQUESTED...WARNING ONLY.

OSL/91  SIMULATION TIME=   0.0   SECONDS.                                                    78.163        12:26:48.17

 DEBUG OUTPUT, BLOCK   3 AT TIME=  0.2000E-02

 TIME     2.0000E-03  DELT     1.0000E-03  DELMIN    0.0         DELMAX   7.2370E 75  TSTART   0.0         FINTIM   2.0000E-03
 CLKTIM   0.0         NALARM   0.0         DELS      0.0         DELMIX   7.2370E 75  DELAOC   7.2370E 75  DELDAC   7.2370E 75
 DELSTF   7.2370E 75  DELMRK   7.2370E 75  IAXLE     0.0         AKT1     1.2500E 03  AKT2     1.2500E 03  AKT3     1.2500E 03
 AKT4     1.2500E 03  RF      -2.4200E 04  RR       -6.9000E 04  TSF      3.2250E 01  TSR      4.3250E 01  TF       5.7300E 01
 TR       5.7500E 01  HFC      6.3000E-01  HRC       2.2200E 00  ZF       1.6010E 01  ZR       1.5800E 01  CFP      7.3000E 01
 CRP      6.0000E 01  A        4.9610E 01  B         6.0390E 01  AMS      7.3000E 00  AMUF     9.3700E-01  AMUR     8.8800E-01
 AKF      7.0000E 02  AKR3     2.1000E 02  AKR4      2.1000E 02  IF       4.9800E 02  IR       4.5900E 02  SCALE    2.0000E 03
 AIX      7.3300E 03  AIY      2.5740E 04  AIZ       2.9700E 04  AIXZ     2.5000E 02  F3F1     8.0000E 01  F3F2     2.3000E 01
 F3R3     1.5220E 02  F3R4     4.9000E 01  OMCNIF    0.0         OMCNIR   0.0         GEE      3.8640E 02  BETA     2.5000E-01
 CTIN     5.0000E-03  UO       7.0400E 02  VO        1.3000E 01  WO       5.0000E 00  PO       4.0000E-02  QO       3.7000E-02
 RO       2.0000E-02  THEO    -2.0900E-03  PHIO     -3.0000E-03  PSIO     2.0000E-03  DEL1     3.8300E-01  DEL1DT   1.0000E 01
 DEL2     8.6600E-01  DEL2DT   1.5000E 01  DEL3      2.0000E-01  DEL4     3.0000E-01  DEL3DT   5.0000E 00  DEL4DT   7.0000E 00
 DELF     8.0000E-01  DELFDT   2.5000E 01  PHIF      2.0000E-02  PHIFO    6.0000E-01  SNPHIF  -1.6300E 02  DELRDT   2.0000E 01
 PHIRO    5.5000E-01  DELR     6.0000E-01  PHIR      1.8950E-02  ANTI1    8.7400E 02  ANTI2    8.7400E 02  ANTI3    6.9200E 02
 ANTI4    6.9200E 02  FYU1    -3.3450E 01  FYU2      3.3450E 01  FYU3    -1.0000E 01  FYU4     1.0000E 01  SFXU    -2.0000E 01
 SFYU     3.0000E 01  SFZS    -1.0900E 03  FZU1     -9.7200E 02  FZU2    -9.7200E 02  FZU3    -8.4400E 02  FZU4    -8.4400E 02
 SNPHIU  -1.1100E 02  SNTHEU  -2.7400E 02  SNPSIU   -7.5500E 02  SNPHIR  -1.6300E 02  RPS1     5.7010E 01  RPS2     5.7010E 01
 RPS3     5.6550E 01  RPS4     5.6550E 01  RPS200    0.0         RPS100   0.0         RPS400   0.0         RPS300   0.0
 ZZ0001   0.0         P        4.0000E-02  Q         3.7000E-02  R        2.0000E-02  U        7.0400E 02  V        1.3000E 01
```

W	5.0000E 00	THE	-2.0900E-03	PHI	-3.0000E-03	PSI	2.0000E-03	COSTHE	1.0000E 00	SINPHI	-3.0000E-03
SINTHE	-2.0900E-03	COSPHI	1.0000E 00	F2	1.6000E-03	Q2	1.3690E-03	R2	4.0000E-04	QR	7.4000E-04
PR	8.0000E-04	WP	2.0000E-01	VR	2.6000E-01	WQ	1.8500E-01	UR	1.4080E 01	UQ	2.6048E 01
PQ	1.4800E-03	VP	5.2000E-01	TFO2	2.8650E 01	TRO2	2.8750E 01	TSFO2	1.6125E 01	TSRO2	2.1625E 01
G	3.8640E 02	SM	9.1250E 00	GAM1	-7.1418E 00	ZZ0002	0.0	GAM2	3.0314E 01	GAM3	3.0314E 01
GAM4	0.0	GAM5	5.5446E 03	GAM6	8.2370E 01	GAM7	1.3701E 03	GAM8	0.0	GAM9	1.7917E 02
AIXP	5.0361E 02	AIYP	5.0361E 02	AIZP	6.5016E 03	AIXZP	-9.8066E 01	AIXXP	7.8336E 03	AIYYP	2.6244E 04
AIZZP	3.6202E 04	DAC00	3.3221E 00	DAC01	-7.8266E-01	DAC02	-7.8266E-01	DAC03	3.3221E 00	DAC04	3.8698E-03
DAC05	1.9395E-02	DAC06	1.7490E-01	DAC07	0.0	DAC08	1.2766E-04	DAC09	1.1551E-03	DAC10	9.5261E-03
DAC11	-3.7368E-03	DAC12	5.2206E-02	DAC13	0.0	DAC14	3.8105E-05	DAC15	4.1969E-03	DAC16	-1.9728E-04
DAC17	0.0	DAC20	5.5710E 01	DAC21	5.5710E 01	DAC22	6.4760E 01	DAC23	6.4760E 01	DAC26	-2.5258E 00
DAC27	3.6487E 00	DAC28	-9.9643E 01	DAC29	-1.4496E-02	DAC30	-9.7741E-03	DAC31	-2.1637E-02	DAC32	3.6920E 03
DAC33	3.6920E 03	DAC34	3.1510E 03	DAC35	3.1510E 03	DAC37	8.7400E 02	DAC38	8.7400E 02	DAC39	6.9200E 02
DAC40	6.9200E 02	DAC41	-2.0747E 03	DAC42	-3.2731E-01	DAC43	-1.9009E 03	DAC44	-3.5512E-01	ZET1	1.1225E 00
ZET2	4.7750E-01	ZET3	1.0098E 00	ZET4	1.9021E-01	ZET1CT	3.4675E 01	ZET2OT	1.5325E 01	ZET3DT	3.1894E 01
ZET4CT	8.1063E 00	F1F1	7.3000E 01	F1F2	7.3000E 01	F1R3	6.0000E 01	F1R4	6.0000E 01	F2F1	7.8575E 02
F2F2	3.3425E 02	F2R3	2.1206E 02	F2R4	3.9943E 01	S1	-4.9741E 01	S2	4.5876E 02	S3	2.9798E 02
S4	5.7329E 02	AUXRL1	0.0	AUXRL2	0.0	AUXRL3	0.0	AUXRL4	0.0	SUMSI	1.2803E 03
UDT	-1.6472E 00	VDT	-1.1392E 01	WDT	1.3690E 02	QDT	-1.2424E 00	RDT	-1.8673E-02	PSIDT	1.9889E-02
PHIOT	3.9958E-02	THEDT	3.7060E-02	PDT	1.8435E 00	DELFDD	-1.7249E 03	PHIFDD	-2.9762E 01	DELRDD	-8.2297E 02
PHIRDD	-2.6313E 01	DELPOD	0.0	DEL1DD	0.0	DEL2DD	0.0	DELPDR	0.0	DEL3DD	0.0
DEL4DD	0.0	RPS1DT	3.3203E-02	RPS2DT	3.3203E-02	RPS3DT	6.0083E-01	RPS4DT	6.0083E-01	P000	4.6250E-02
P005	5.8667E-01	P020	8.3600E-03	P025	5.0000E-04	P075	2.0000E-02	P086	6.0000E-02	P101	5.7010E-01
P110	5.6550E-01	F111	0.0	F114	0.0	P050	0.0	P119	0.0	Q002	6.0000E-02
Q004	5.5000E-02	Q007	1.8950E-02	Q009	8.0000E-02	Q012	5.0000E-03	Q014	1.3000E-02	Q017	2.0000E-02
Q019	5.0000E-02	Q022	2.5000E-01	Q024	2.0000E-01	Q027	4.5000E-03	A000	4.6250E-02	A005	5.8667E-01
A007	2.0000E-02	A010	1.3000E-02	A012	5.0000E-03	A015	5.0000E-02	A020	-8.3600E-03	A025	4.5000E-03
A027	5.0000E-04	A040	1.8950E-02	A095	-5.5000E-02	A050	-2.5000E-01	A055	8.0000E-02	A070	-6.0000E-02
A075	2.0000E-02	A080	-2.0000E-01	A085	6.0000E-02	A100	-5.7010E-01	A105	-5.7010E-01	A110	-5.6550E-01
A115	-5.6550E-01	A001	9.9444E-03	A002	2.0591E-03	A004	-8.0000E-02	A008	-3.0000E-03	A009	6.0000E-02
A011	7.5945E-03	A014	6.0000E-02	A016	2.4870E-02	A017	4.1050E-02	A018	6.5000E-05	A019	0.0
A021	-2.2938E-01	A022	6.0083E-05	A023	2.6000E-04	A024	-1.8950E-02	A026	-1.4899E-01	A028	4.5906E-06
A029	0.0	A030	-1.6162E-01	A031	-3.3425E-02	A032	-2.0000E-02	A034	-2.4870E-02	A035	-6.8450E-01
A036	-2.1206E-02	A037	2.2938E-01	A039	3.4675E-01	A041	7.0766E-02	A042	1.5325E-01	A043	-2.9333E-03
A044	5.5000E-02	A045	-3.9943E-03	A046	4.1192E-01	A047	8.1063E-02	A049	3.1894E-01	A051	-2.8664E-01
A052	-6.0000E-02	A053	-2.7133E-02	A056	3.3203E-06	A057	-2.0591E-03	A058	4.4535E-05	A059	-6.5000E-05
A060	3.3203E-06	A061	-1.7538E-01	A062	-3.0000E-03	A063	-2.3125E-03	A066	1.5039E-02	A067	1.0000E 00
A068	-1.0000E-03	A069	0.0	A071	-1.0146E-01	A072	1.0000E 00	A076	6.0083E-05	A077	2.0900E-03
A078	-9.9999E-01	A081	-1.5362E-01	A082	2.8664E-01	A083	1.3875E-04	A084	-2.0900E-03	A086	2.6308E-01
A087	2.3125E-03	A088	-5.0000E-03	A090	-7.8575E-02	A091	-2.9768E-02	A092	2.0000E-04	A093	4.6250E-02
A096	-3.7060E-02	A098	1.5000E-05	A101	6.2120E-01	A103	-9.9445E-03	A104	1.4899E-01	A106	8.8257E-04
A108	-2.0784E-05	A109	6.8450E-01	A111	-4.0998E-02	A112	-1.5540E-01	A113	5.9380E-05	A114	-9.9288E-01
A116	9.3365E-04	A117	0.0	A118	1.4845E-05	A119	-3.0911E-01	D000	3.8825E-01	D005	3.4317E-04
D007	-2.3043E-01	D010	2.8479E-03	D012	1.1671E-03	D015	-3.4225E-01	D020	-3.7060E-02	D025	1.4984E-02
D027	-1.2431E-03	D040	-1.3750E-01	D050	-4.3124E-01	D055	-6.2500E-01	D070	-7.4405E-01	D075	-1.5000E-01
D080	-2.0574E-01	D085	-5.0000E-01	D095	-6.5781E-01	D100	8.3008E-06	D105	8.3008E-06	D110	1.5021E-04
D115	1.5021E-04	DA00	-6.6442E-02	DA01	-7.8266E-03	DA02	1.5653E-02	DA03	-5.3154E-03	DA04	9.6744E-02
DA05	4.8488E-02	DA06	-8.7448E-02	DA07	0.0	DA08	3.1914E-01	DA09	3.8504E-01	DA10	3.8105E-02
DA11	-1.4947E-02	DA12	-4.1765E-02	DA13	0.0	DA14	3.8105E-01	DA15	-3.3575E-03	DA16	1.9728E-02
DA17	0.0	DA20	-5.5710E-02	DA21	-5.5710E-02	DA22	-6.4760E-02	DA23	-6.4760E-02	DA26	-6.3144E-03
DA27	3.6487E-03	DA28	-9.9643E-02	DA29	-5.1772E-04	DA30	-9.7741E-04	DA31	-2.1637E-03	DA32	-1.8460E-01
DA33	-1.8460E-01	DA34	-1.5755E-01	DA35	-1.5755E-01	DA37	8.7400E-02	DA38	8.7400E-02	DA39	6.9200E-02
DA40	6.9200E-02	DA41	-5.1868E-02	DA42	-8.1827E-04	DA43	-4.7522E-02	DA44	-8.8780E-04	T040	3.4675E-01
T041	1.5325E-01	T042	2.4225E-04	T043	8.1063E-02	T053	3.1894E-01	T054	2.0000E-02	T055	4.6250E-02
T056	5.0000E-03	T057	-1.5362E-01	T058	9.3365E-04	T059	6.2120E-01	T070	1.5540E-01	T071	1.0000E-04
T072	-3.0000E-04	T073	5.0000E-04	T074	7.4225E-04	T075	4.4225E-04	T076	1.4800E-04	T077	1.4800E-04
T078	-2.3052E-01	T079	9.2500E-05	T080	-8.0000E-02	T082	-1.5220E-01	T083	-4.9000E-02	T088	-2.3000E-02
ZZ0003	0.0	ZZ0004	0.0	DUMMY	0.0						

```
         *** OSL/91  SIMULATION DATA ***                                              78.163        12:26:48.41
     PARAM IAXLE = 1
     PARAM AKT1=1295.,AKT2=1295.,AKT3=1295.,AKT4=1295.
     PARAM RF=151000.,RR=0.0
     PARAM TSF=0.0,TSR=43.,TF=61.5,TR=61.
     PARAM HFC=3.,HRC=2.5,ZF=9.35,ZR=9.35
     PARAM CFP=36.,CRP=50.,A=48.,B=61.
     PARAM AMS=8.13,AMUF=.484,AMUR=.789
     PARAM AKF=100.2,AKR3=114.,AKR4=114.
     PARAM IF=3.3,IR=600.,SCALE=2000.
     PARAM AIX=2940.,AIY=14700.,AIZ=22500.,AIXZ=230.
     PARAM F3F1=15.2,F3F2=22.5,F3R3=152.2,F3R4=48.6
     INCON SFZS= -100.
     END

***OSL MESSAGE 20***   NO OUTPUT REQUESTED...WARNING ONLY.

OSL/91  SIMULATION TIME=   0.01 SECONDS.                                                  78.163        12:26:48.54

 DEBUG OUTPUT, BLOCK    3 AT TIME=  0.2000E-02
```

TIME	2.0000E-03	DELT	1.0000E-03	DELMIN	0.0	DELMAX	7.2370E 75	TSTART	0.0	FINTIM	2.0000E-03
CLKTIM	0.0	NALARM	0.0	DELS	0.0	DELNIX	7.2370E 75	DELADC	7.2370E 75	DELDAC	7.2370E 75
DELSTP	7.2370E 75	DELMRK	7.2370E 75	IAXLE	1.0000E 00	AKT1	1.2950E 03	AKT2	1.2950E 03	AKT3	1.2950E 03
AKT4	1.2950E 03	RF	1.5100E 05	RR	0.0	TSF	0.0	TSR	4.3000E 01	TF	6.1500E 01
TR	6.1000E 01	HFC	3.0000E 00	HRC	2.5000E 00	ZF	9.3500E 00	ZR	9.3500E 00	CFP	3.6000E 01
CRP	5.0000E 01	A	4.8000E 01	B	6.1000E 01	AMS	8.1300E 00	AMUF	4.8400E-01	AMUR	7.8900E-01
AKF	1.0020E 02	AKR3	1.1400E 02	AKR4	1.1400E 02	IF	3.3000E 00	IR	6.0000E 02	SCALE	2.0000E 03
AIX	2.9400E 03	AIY	1.4700E 04	AIZ	2.2500E 04	AIXZ	2.3000E 02	F3F1	1.5200E 01	F3F2	2.2500E 01
F3R3	1.5220E 02	F3R4	4.8600E 01	OMCNIF	0.0	OMCNIR	0.0	GEE	3.8640E 02	BETA	2.5000E-01
OTIN	5.0000E-03	UO	7.0400E 02	VO	1.3000E 01	WO	5.0000E 00	PO	4.0000E-02	QO	3.7000E-02
RC	2.0000E-02	THEO	-2.0900E-03	PHIC	-3.0000E-03	PSIO	2.0000E-03	DEL1	3.8300E-01	DEL1DT	1.0000E 01
DEL2	8.6600E-01	DEL2DT	1.5000E 01	DEL3	2.0000E-01	DEL4	3.0000E-01	DEL3DT	5.0000E 00	DEL4DT	7.0000E 00
DELF	6.0000E-01	DELFDT	2.5000E 01	PHIF	2.0000E-02	PHIFO	6.0000E-01	SNPHIF	-1.6300E 02	DELRDT	2.0000E 01
PHIRC	5.5000E-01	DELR	6.0000E-01	PHIR	1.8950E-02	ANTI1	8.7400E 02	ANTI2	8.7400E 02	ANTI3	6.9200E 02
ANTI4	6.9200E 02	FYU1	-3.3450E 01	FYU2	3.3450E 01	FYU3	-1.0000E 01	FYU4	1.0000E 01	SFXU	-2.0000E 01
SFYU	3.0000E 01	SFZS	-1.0000E 02	FZU1	-9.7200E 02	FZU2	-9.7200E 02	FZU3	-8.4400E 02	FZU4	-8.4400E 02
SNPHIU	-1.1100E 02	SNTHEU	-2.7400E 02	SNPSIU	-7.5500E 02	SNPHIR	-1.6300E 02	RPS1	5.7010E 01	RPS2	5.7010E 01
RPS3	5.6550E 01	RPS4	5.6550E 01	RPS2DO	0.0	RPS1DO	0.0	RPS4DO	0.0	RPS3DO	0.0
ZZ0001	0.0	P	4.0000E-02	Q	3.7000E-02	R	2.0000E-02	U	7.0400E 02	V	1.3000E 01
W	5.0000E 00	THE	-2.0900E-03	PHI	-3.0000E-03	PSI	2.0000E-03	COSTHE	1.0000E 00	SINPHI	-3.0000E-03
SINTHE	-2.0900E-03	COSPHI	1.0000E 00	F2	1.6000E-03	Q2	1.3690E-03	R2	4.0000E-04	QR	7.4000E-04
PR	8.0000E-04	WP	2.0000E-01	VR	2.6000E-01	WQ	1.8500E-01	UR	1.4080E 01	UQ	2.6048E 01
PQ	1.4800E-03	VP	5.2000E-01	TFO2	3.0750E 01	TRO2	3.0500E 01	TSFO2	0.0	TSRO2	2.1500E 01
G	3.8640E 02	SM	9.4030E 00	GAM1	-2.4897E 01	ZZ0002	0.0	GAM2	1.2678E 01	GAM3	1.2678E 01
GAM4	-3.5942E 00	GAM5	3.5934E 03	GAM6	4.3660E 01	GAM7	4.3530E 02	GAM8	-7.4415E 01	GAM9	-1.3444E 03
AIXP	1.2629E 02	AIYP	1.2629E 02	AIZP	5.1087E 03	AIXZP	-2.4716E 02	AIXXP	3.0663E 03	AIYYP	1.4826E 04
AIZZP	2.7609E 04	DAC00	1.3483E 00	OAC01	-2.6478E 00	OAC02	-2.6478E 00	DAC03	1.3483E 00	DAC04	4.1347E-03
OAC05	-5.5950E-03	DAC06	1.4196E-01	DAC07	-1.1722E-03	OAC08	3.2613E-04	DAC09	8.5512E-04	OAC10	1.5513E-02
DAC11	-1.6670E-02	OAC12	2.9360E-02	DAC13	-2.4242E-04	DAC14	6.7448E-05	OAC15	-6.2139E-04	DAC16	-9.0178E-04
OAC17	-1.3019E-04	DAC20	5.5710E 01	DAC21	5.5710E 01	DAC22	6.4760E 01	DAC23	6.4760E 01	DAC26	-2.2988E 00
DAC27	3.3762E 00	DAC28	-1.2300E 01	DAC29	-3.8052E-02	OAC30	-1.7432E-02	OAC31	-3.0217E-02	DAC32	3.6920E 03
DAC33	3.6920E 03	DAC34	3.1510E 03	DAC35	3.1510E 03	DAC37	8.7400E 02	DAC38	8.7400E 02	DAC39	6.9200E 02
DAC40	6.9200E 02	DAC41	-4.0030E 03	DAC42	-4.0301E 03	OAC43	-2.1394E 03	DAC44	-2.7167E-01	ZET1	3.8300E-01
ZET2	8.6600E-01	ZET3	1.0074E 00	ZET4	1.9258E-01	ZET1DT	1.0000E 01	ZET2DT	1.5000E 01	ZET3DT	3.1825E 01
ZET4DT	8.1750E 00	F1F1	3.6000E 01	F1F2	3.6000E 01	F1R3	5.0000E 01	F1R4	5.0000E 01	F2F1	3.8377E 01
F2F2	8.6773E 01	F2R3	1.1485E 02	F2R4	2.1954E 01	S1	8.0371E 02	S2	7.0944E 02	S3	3.7495E 02
S4	5.7145E 02	AUXRL1	1.9283E 01	AUXRL2	-1.9283E 01	AUXRL3	0.0	AUXRL4	0.0	SUMSI	2.4596E 03
UOT	-1.4220E 00	VDT	-1.1660E 01	WOT	9.7097E 01	QDT	9.8721E-01	ROT	-1.6655E-02	PSIDT	1.9889E-02
PHIDT	3.9958E-02	THEDT	3.7060E-02	PDT	4.5090E-01	DELFDO	-1.7249E 03	PHIFDO	-2.9762E 01	DELROD	-9.8067E 02

PHIRDD	-1.7703E 01	DELPDD	3.6218E 02	DEL1DD	-5.7439E 02	DEL2DD	-1.0836E 03	DELPDR	0.0	DEL3DD	0.0
DEL4DD	0.0	RPS1DT	3.3203E-02	RPS2DT	3.3203E-02	RPS3DT	6.0083E-01	RPS4DT	6.0083E-01	P000	4.6250E-02
P005	5.8667E-01	P020	8.3600E-03	P023	5.0000E-04	P075	8.6600E-02	P086	6.0000E-02	P101	5.7010E-01
P110	5.6550E-01	P111	0.0	P114	0.0	P050	0.0	P119	0.0	Q002	1.5000E-01
Q004	5.5000E-02	Q007	1.8950E-02	Q009	3.8300E-02	Q012	5.0000E-03	Q014	1.3000E-02	Q017	2.0000E-02
Q019	5.0000E-02	Q022	1.0000E-01	Q024	2.0000E-01	Q027	4.5000E-03	A000	4.6250E-02	A005	5.8667E-01
A007	2.0000E-02	A010	1.3000E-02	A012	5.0000E-03	A015	5.0000E-02	A020	-8.3600E-03	A025	4.5000E-03
A027	5.0000E-04	A040	1.8950E-02	A095	-5.5000E-02	A050	-1.0000E-01	A055	3.8300E-02	A070	-1.5000E-01
A075	8.6600E-02	A080	-2.0000E-01	A085	6.0000E-02	A100	-5.7010E-01	A105	-5.7010E-01	A110	-5.6550E-01
A115	-5.6550E-01	A001	9.9444E-03	A002	1.7775E-03	A004	-3.8300E-02	A008	-3.0000E-03	A009	-4.8300E-02
A011	7.7734E-03	A014	1.5000E-01	A016	-4.0185E-01	A017	4.1050E-02	A018	6.5000E-05	A019	0.0
A021	-3.5472E-01	A022	6.0083E-05	A023	2.6000E-04	A024	-1.8950E-02	A026	-1.8748E-01	A028	4.5906E-06
A029	1.9283E-03	A030	7.4504E-02	A031	-8.6773E-03	A032	-8.6600E-02	A034	4.0185E-01	A035	-4.8548E-01
A036	-1.1485E-02	A037	3.5472E-01	A039	1.0000E-01	A041	6.6301E-03	A042	1.5000E-01	A043	-2.9333E-03
A044	5.5000E-02	A045	-2.1954E-03	A046	4.1192E-01	A047	8.1750E-02	A049	3.1825E-01	A051	-2.8572E-01
A052	-6.0000E-02	A053	-2.7133E-02	A056	3.3203E-06	A057	-1.7775E-03	A058	4.4535E-05	A059	-6.5000E-05
A060	3.3203E-06	A061	-3.0253E-01	A062	-3.0000E-03	A063	-2.3125E-03	A066	1.5059E-02	A067	1.0000E 00
A068	-1.0000E-03	A069	3.4719E-03	A071	-3.6316E-01	A072	1.0000E 00	A076	6.0083E-05	A077	2.0900E-03
A078	-9.9999E-01	A081	-3.7575E-02	A082	2.8572E-01	A083	1.3875E-04	A084	-2.0900E-03	A086	2.8865E-01
A087	2.3125E-03	A088	-5.0000E-03	A090	-3.8377E-03	A091	-2.1123E-02	A092	2.0000E-04	A093	4.6250E-02
A096	-3.7060E-02	A098	1.5000E-05	A101	-4.9361E-01	A103	-9.9445E-03	A104	1.8748E-01	A106	8.8257E-04
A108	-2.0784E-05	A109	4.8548E-01	A111	1.4493E-02	A112	1.2330E-01	A113	2.8428E-05	A114	-2.4875E-01
A116	8.3273E-04	A117	0.0	A118	6.4279E-05	A119	-7.8634E-01	D000	-3.0850E-01	D005	2.9624E-04
D007	-5.6362E-02	D010	2.9150E-03	D012	1.0409E-03	D015	-2.4274E-01	D020	-3.7060E-02	D025	1.4984E-02
D027	-1.2431E-03	D040	-1.3750E-01	D050	-1.4360E-01	D055	-2.5000E-01	D070	-2.7090E-01	D075	-3.7500E-01
D080	-2.4517E-01	D085	-5.0000E-01	D095	-4.4257E-01	D100	8.3008E-06	D105	8.3008E-06	D110	1.5021E-04
D115	1.5021E-04	DA00	-2.6966E-02	DA01	-2.6478E-02	DA02	5.2955E-02	DA03	-2.1573E-03	DA04	1.0337E-01
DA05	-1.3987E-02	DA06	-7.0981E-02	DA07	1.1722E-03	DA08	8.1532E-01	DA09	2.8504E-01	DA10	6.2052E-02
DA11	-6.6680E-02	DA12	-2.3488E-02	DA13	2.4242E-03	DA14	6.7448E-01	DA15	4.9711E-04	DA16	9.0178E-02
DA17	-1.0415E-04	DA20	-5.5710E-02	DA21	-5.5710E-02	DA22	-6.4760E-02	DA23	-6.4760E-02	DA26	-5.7469E-03
DA27	3.3762E-03	DA28	-1.2300E-02	DA29	-1.3590E-03	DA30	-1.7432E-03	DA31	-3.0217E-03	DA32	-1.8460E-01
DA33	-1.8460E-01	DA34	-1.5755E-01	DA35	-1.5755E-01	DA37	8.7400E-02	DA38	8.7400E-02	DA39	6.9200E-02
DA40	6.9200E-02	DA41	-1.0007E-01	DA42	-1.0075E-01	DA43	-5.3485E-02	DA44	-6.7917E-04	T040	1.0000E-01
T041	1.5000E-01	T042	2.4225E-04	T043	8.1750E-02	T053	3.1825E-01	T054	2.0000E-02	T055	4.6250E-02
T056	5.0000E-03	T057	-3.7575E-02	T058	8.3273E-04	T059	-4.9361E-01	T070	-1.2330E-01	T071	1.0000E-04
T072	-3.0000E-04	T073	5.0000E-04	T074	7.4225E-04	T075	4.4225E-04	T076	1.4800E-04	T077	1.4800E-04
T078	-5.6454E-02	T079	9.2500E-05	T080	-1.5200E-02	T082	-1.5220E-01	T083	-4.8600E-02	T088	-2.2500E-02
ZZ0003	0.0	ZZ0004	0.0	DUMMY	0.0						

```
          *** DSL/91  SIMULATION DATA ***                                       78.163        12:26:48.67
     PARAM IAXLE = 2
     PARAM AKT1=746.,AKT2=746.,AKT3=956.,AKT4=956.
     PARAM RR=28300.,TSR=50.,TF=53.8,TR=51.5
     PARAM HFC=2.4,HRC=3.4,ZF=10.8,ZR=11.2
     PARAM CFP=35.,CRP=40.,A=55.9,B=39.9
     PARAM AMS=5.5,AMUF=0.36,AMUR=0.57
     PARAM AKF=101.1,AKR3=115.,AKR4=115.
     PARAM IR=800.,RF=93000.,SCALE=1000.
     PARAM AIX=2060.,AIY=9927.,AIZ=9385.,AIXZ=0.0
     PARAM F3R3=30.,F3R4=42.
     INCON ANTI1=384.6,ANTI2=384.6,ANTI3=623.7,ANTI4=623.7,SFZS=-400.
     END

***DSL MESSAGE 20***   NO OUTPUT REQUESTED...WARNING ONLY.

DSL/91  SIMULATION TIME=   0.01 SECONDS.                                        78.163        12:26:48.80

 DEBUG OUTPUT, BLOCK   3 AT TIME=  0.2000E-02
```

TIME	2.0000E-03	DELT	1.0000E-03	DELMIN	0.0	DELMAX	7.2370E 75	TSTART	0.0	FINTIM	2.0000E-03
CLKTIM	0.0	NALARM	0.0	DELS	0.0	DELNIX	7.2370E 75	DELAOC	7.2370E 75	DELDAC	7.2370E 75
DELSTF	7.2370E 75	DELMRK	7.2370E 75	IAXLE	2.0000E 00	AKT1	7.4600E 02	AKT2	7.4600E 02	AKT3	9.5600E 02
AKT4	9.5600E 02	RF	9.3000E 04	RR	2.8300E 04	TSF	0.0	TSR	5.0000E 01	TF	5.3800E 01
TR	5.1500E 01	HFC	2.4000E 00	HRC	3.4000E 00	ZF	1.0800E 01	ZR	1.1200E 01	CFP	3.5000E 01
CRP	4.0000E 01	A	5.5900E 01	B	3.9900E 01	AMS	5.5000E 00	AMUF	3.6000E-01	AMUR	5.7000E-01
AKF	1.0110E 02	AKR3	1.1500E 02	AKR4	1.1500E 02	IF	3.3000E 00	IR	8.0000E 02	SCALE	1.0000E 03
AIX	2.0600E 03	AIY	9.9270E 03	AIZ	9.3850E 03	AIXZ	0.0	F3F1	1.5200E 01	F3F2	2.2500E 01
F3R3	3.0000E 01	F3R4	4.2000E 01	OMCNIF	0.0	OMCNIR	0.0	GEE	3.8640E 02	BETA	2.5000E-01
OTIN	5.0000E-03	UO	7.0400E 02	VO	1.3000E 01	WO	5.0000E 00	PO	4.0000E-02	CO	3.7000E-02
RC	2.0000E-02	THEO	-2.0900E-03	PHIO	-3.0000E-03	PSIC	2.0000E-03	DEL1	3.8300E-01	DEL1DT	1.0000E 01
DEL2	8.6600E-01	DEL2DT	1.5000E 01	DEL3	2.0000E-01	DEL4	3.0000E-01	DEL3DT	5.0000E 00	DEL4DT	7.0000E 00
DELF	8.0000E-01	DELFDT	2.5000E 01	PHIF	2.0000E-02	PHIFO	6.0000E-01	SNPHIF	-1.6300E 02	DELRDT	2.0000E 01
PHIRC	5.5000E-01	DELR	6.0000E-01	PHIR	1.8950E-02	ANTI1	3.8460E 02	ANTI2	3.8460E 02	ANTI3	6.2370E 02
ANTI4	6.2370E 02	FYU1	-3.3450E 01	FYU2	3.3450E 01	FYU3	-1.0000E 01	FYU4	1.0000E 01	SFXU	-2.0000E 01
SFYU	3.0000E 01	SFZS	-4.0000E 02	FZU1	-9.7200E 02	FZU2	-9.7200E 02	FZU3	-8.4400E 02	FZU4	-8.4400E 02
SNPHIU	-1.1100E 02	SNTHEU	-2.7400E 02	SNPSIU	-7.5500E 02	SNPHIR	-1.6300E 02	RPS1	5.7010E 01	RPS2	5.7010E 01
RPS3	5.6550E 01	RPS4	5.6550E 01	RPS2DD	0.0	RPS1DD	0.0	RPS4DD	0.0	RPS3DD	0.0
ZZ0001	0.0	P	4.0000E-02	Q	3.7000E-02	R	2.0000E-02	U	7.0400E 02	V	1.3000E 01
W	5.0000E 00	THE	-2.0900E-03	PHI	-3.0000E-03	PSI	2.0000E-03	COSTHE	1.0000E 00	SINPHI	-3.0000E-03
SINTHE	-2.0900E-03	COSPHI	1.0000E 00	F2	1.6000E-03	Q2	1.3690E-03	R2	4.0000E-04	QR	7.4000E-04
PR	8.0000E-04	WP	2.0000E-01	VR	2.6000E-01	WQ	1.8500E-01	UR	1.4080E 01	UQ	2.6048E 01
PQ	1.4800E-03	VP	5.2000E-01	TFO2	2.6900E 01	TRO2	2.5750E 01	TSFO2	0.0	TSRO2	2.5000E 01
G	3.8640E 02	SM	6.4300E 00	GAM1	-2.6190E 00	ZZ0002	0.0	GAM2	1.0639E 01	GAM3	1.0639E 01
GAM4	-3.0726E 00	GAM5	1.3939E 03	GAM6	1.5840E 01	GAM7	1.8163E 02	GAM8	-7.7775E 01	GAM9	2.3018E 02
AIXP	1.2174E 02	AIYP	1.2174E 02	AIZP	2.6708E 03	AIXZP	-3.0501E 01	AIXXP	2.1817E 03	AIYYP	1.0049E 04
AIZZP	1.2056E 04	DAC00	1.6546E 00	DAC01	-4.0731E-01	DAC02	-4.0731E-01	DAC03	1.6546E 00	DAC04	4.8765E-03
DAC05	-1.3980E-02	DAC06	8.3250E-02	DAC07	-1.4083E-03	DAC08	4.5835E-04	DAC09	1.0588E-03	DAC10	0.0
DAC11	-3.0353E-03	DAC12	1.8075E-02	DAC13	-3.0577E-04	DAC14	9.9515E-05	DAC15	-2.5300E-03	DAC16	-2.1724E-04
DAC17	-2.5486E-04	DAC20	5.5710E 01	DAC21	5.5710E 01	DAC22	6.4760E 01	DAC23	6.4760E 01	DAC26	-3.2016E 00
DAC27	4.7642E 00	DAC28	-7.2727E 01	DAC29	-5.0652E-02	DAC30	2.7020E-01	DAC31	-6.3237E-02	DAC32	3.6920E 03
DAC33	3.6920E 03	DAC34	3.1510E 03	DAC35	3.1510E 03	DAC37	3.8460E 02	DAC38	3.8460E 02	DAC39	6.2370E 02
DAC40	6.2370E 02	DAC41	-5.3834E 03	DAC42	-5.4166E 03	DAC43	-2.9567E 03	DAC44	-2.9567E 03	ZET1	3.8300E-01
ZET2	8.6600E-01	ZET3	2.0000E-01	ZET4	3.0000E-01	ZET1DT	1.0000E 01	ZET2DT	1.5000E 01	ZET3DT	5.0000E 00
ZET4DT	7.0000E 00	F1F1	3.5000E 01	F1F2	3.5000E 01	F1R3	4.0000E 01	F1R4	4.0000E 01	F2F1	3.8721E 01
F2F2	8.7553E 01	F2R3	2.3000E 01	F2R4	3.4500E 01	S1	3.1120E 02	S2	2.2403E 02	S3	5.3177E 02
S4	5.0613E 02	AUXRL1	1.5519E 01	AUXRL2	-1.5519E 01	AUXRL3	1.0670E 00	AUXRL4	-1.0670E 00	SUMSI	1.5731E 03
UDT	-2.3210E 00	VDT	-1.0276E 01	WDT	5.3175E 01	QDT	-8.7327E-01	RDT	-5.9568E-02	PSIDT	1.9889E-02
PHIDT	3.9958E-02	THEDT	3.7060E-02	PDT	-1.3580E 00	DELFDD	-1.7249E 03	PHIFDD	-2.9762E 01	DELRDD	-9.8067E 02
PHIRDD	-1.7703E 01	DELPDD	3.0989E 02	DEL1DD	-3.4946E 03	DEL2DD	-4.1784E 03	DELPDR	3.9363E 02	DEL3DD	-7.3776E 02

DEL4CC	-9.2779E 02	RPS1DT	3.3203E-02	RPS2DT	3.3203E-02	RPS3DT	6.0083E-01	RPS4DT	6.0083E-01	P000	4.6250E-02
P005	5.8667E-01	P020	8.3600E-03	P023	5.0000E-04	P075	8.6600E-02	P086	2.0000E-02	P101	5.7010E-01
P110	5.6550E-01	P111	0.0	P114	0.0	P050	0.0	P119	0.0	Q002	1.5000E-01
Q004	7.0000E-02	Q007	3.0000E-02	Q009	3.8300E-02	Q012	5.0000E-03	Q014	1.3000E-02	Q017	2.0000E-02
Q019	5.0000E-02	Q022	1.0000E-01	Q024	5.0000E-02	Q027	4.5000E-03	A000	4.6250E-02	A005	5.8667E-01
A007	2.0000E-02	A010	1.3000E-02	A012	5.0000E-03	A015	5.0000E-02	A020	-8.3600E-03	A025	4.5000E-03
A027	5.0000E-04	A040	3.0000E-02	A095	-7.0000E-02	A050	-1.0000E-01	A055	3.8300E-02	A070	-1.5000E-01
A075	8.6600E-02	A080	-5.0000E-02	A085	2.0000E-02	A100	-5.7010E-01	A105	-5.7010E-01	A110	-5.6550E-01
A115	-5.6550E-01	A001	9.9444E-03	A002	2.9013E-03	A004	-3.8300E-02	A008	-3.0000E-03	A009	-4.8300E-02
A011	6.8504E-03	A014	1.5000E-01	A016	-3.1120E-01	A017	-1.0000E-02	A018	6.5000E-05	A019	1.0670E-03
A021	-2.2403E-01	A022	6.0083E-05	A023	2.6000E-04	A024	-3.0000E-02	A026	-5.3177E-01	A028	2.2267E-05
A029	1.5519E-03	A030	-1.1493E-01	A031	-8.7553E-03	A032	-8.6600E-02	A034	3.1120E-01	A035	-2.6587E-01
A036	-2.3000E-03	A037	2.2403E-01	A039	1.0000E-01	A041	-3.0049E-02	A042	1.5000E-01	A043	-2.9333E-03
A044	7.0000E-02	A045	-3.4500E-03	A046	4.1192E-01	A047	7.0000E-02	A049	5.0000E-02	A051	-5.0613E-01
A052	-2.0000E-02	A053	-2.7133E-02	A056	3.3203E-06	A057	-2.9013E-03	A058	1.4645E-05	A059	-6.5000E-05
A060	3.3203E-06	A061	-2.8602E-01	A062	-3.0000E-03	A063	-2.3125E-03	A066	1.5039E-02	A067	1.0000E 00
A068	-1.0000E-03	A069	-9.1274E-03	A071	-2.9919E-01	A072	1.0000E 00	A076	6.0083E-05	A077	2.0900E-03
A078	-9.9999E-01	A081	1.1316E-01	A082	5.0613E-01	A083	1.3875E-04	A084	-2.0900E-03	A086	4.1412E-01
A087	2.3125E-03	A088	-5.0000E-03	A090	-3.8721E-03	A091	6.6008E-03	A092	2.0000E-04	A093	4.6250E-02
A096	-3.7060E-02	A098	1.5000E-05	A101	4.3664E-01	A103	-9.9445E-03	A104	5.3177E-01	A106	8.8257E-04
A108	-2.0784E-05	A109	2.6587E-01	A111	2.3449E-02	A112	-1.0926E-01	A113	2.8428E-05	A114	-5.1018E-01
A116	2.9984E-03	A117	-8.7371E-03	A118	6.4279E-05	A119	-9.1496E-02	D000	2.7290E-01	D005	4.8355E-04
D007	1.6975E-01	D010	2.5689E-03	D012	3.7480E-03	D015	-1.3294E-01	D020	-3.7060E-02	D025	1.4984E-02
D027	-1.2431E-03	D040	-1.7500E-01	D050	-8.7364E-01	D055	-2.5000E-01	D070	-1.0446E 00	D075	-3.7500E-01
D080	-1.8444E-01	D085	-1.2500E-01	D095	-2.3195E-01	D100	8.3008E-06	D105	8.3008E-06	D110	1.5021E-04
D115	1.5021E-04	DA00	-3.3093E-02	DA01	-4.0731E-03	DA02	8.1462E-03	DA03	-2.6474E-03	DA04	1.2191E-01
DA05	-3.4950E-02	DA06	-4.1625E-02	DA07	1.4083E-03	DA08	5.7294E-01	DA09	3.5292E-01	DA10	0.0
DA11	-1.2141E-02	DA12	-1.4460E-02	DA13	3.0577E-03	DA14	4.9757E-01	DA15	2.0240E-03	DA16	2.1724E-02
DA17	-2.0389E-04	DA20	-5.5710E-02	DA21	-5.5710E-02	DA22	-6.4760E-02	DA23	-6.4760E-02	DA26	-8.0039E-03
DA27	4.7642E-03	DA28	-7.2727E-02	DA29	-1.8090E-03	DA30	2.7020E-02	DA31	-6.3237E-03	DA32	-1.8460E-01
DA33	-1.8460E-01	DA34	-1.5755E-01	DA35	-1.5755E-01	DA37	3.8460E-02	DA38	3.8460E-02	DA39	6.2370E-02
DA40	6.2370E-02	DA41	-1.3458E-01	DA42	-1.3542E-01	DA43	-7.3919E-02	DA44	-7.3919E-02	T040	1.0000E-01
T041	1.5000E-01	T042	2.4225E-04	T043	7.0000E-02	T053	5.0000E-02	T054	2.0000E-02	T055	4.6250E-02
T056	5.0000E-03	T057	1.1316E-01	T058	2.9984E-03	T059	4.3664E-01	T070	1.0926E-01	T071	1.0000E-04
T072	-3.0000E-04	T073	5.0000E-04	T074	7.4225E-04	T075	4.4225E-04	T076	1.4800E-04	T077	1.4800E-04
T078	1.6965E-01	T079	9.2500E-05	T080	-1.5200E-02	T082	-3.0000E-02	T083	-4.2000E-02	T088	-2.2500E-02
ZZ0003	0.0	ZZ0004	0.0	DUMMY	0.0						

H-2. IBM 360/91 Fortran Digital Program

This section contains the computer listing of the IBM 360/91 Fortran digital program.

H-2.1 Subroutines

H-2.1.1 MAIN

Presented here is the Fortran listing for the MAIN program. Control of the program flow is performed in this program.

```
C     VEHICLE HANDLING  MODEL C                                         MAIN  10
C     MAIN PROGRAM                                                      MAIN  10
C*********************************************************************
C     THIS PROGRAM CONTROLS THE PROGRAM FLOW
C*********************************************************************
      LOGICAL TRSL,LOGDUM
 8888 CONTINUE                                                          MAIN  30
      CALL OSXNTL                                                       MAIN  40
      CALL USERIN                                                       MAIN  50
      CALL VHTPIC                                                       MAIN  60
      CALL NITIAL                                                       MAIN  70
      CALL SBPG22                                                       MAIN  80
      CALL NTIAL1                                                       MAIN  90
      CALL POTSET                                                       MAIN 100
 999  CONTINUE
      CALL NTRACT(&8888,&1000,&2000,&3000)                              MAIN 110
 1000 CONTINUE                                                          MAIN 120
      CALL VHTPIC                                                       MAIN 130
      CALL NITIAL                                                       MAIN 140
      CALL SBPG22                                                       MAIN 150
      CALL NTIAL1                                                       MAIN 160
      CALL POTSET                                                       MAIN 170
      CALL NTRAT1(&8888,&1000,&2000,&3000)                              MAIN 180
 2000 CONTINUE                                                          MAIN 190
      LOGDUM=TRSL(00)
      CALL RTMON                                                        MAIN 200
      IF(TRSL(00)) GO TO 999
      CALL CMPVAR                                                       MAIN 210
      CALL NTRAT2(&8888,&1000,&2000,&3000)                              MAIN 220
 3000 CONTINUE                                                          MAIN 230
C
C     THE FOLLOWING STATEMENTS ARE REQUIRED FOR OVERLAY
C
      CALL RTMONT                                                       OVERLAY
      CALL RACN(1,IRACNE)                                               OVERLAY
      CALL CHKIO                                                        OVERLAY
      CALL WRTOFF                                                       OVERLAY
      CALL RDOFF                                                        OVERLAY
      STOP                                                              MAIN 240
      END                                                               MAIN 250
```

H-2.1.2 OSXNTL

Presented here is the Fortran listing for the OSXNTL subprogram. The following is performed in OSXNTL:

1. Initialization of the OS options executive which includes the reading of data cards for table and track variables, analog-to-digital and digital-to-analog converter (ADC and DAC) assignments, and all initial values for interactive variables.

2. Communication initialization with the hybrid operator's station.

```
C     SUBROUTINE OSXNTL
      SUBROUTINE OSXNTL
C ***********************************************************************
C
C     THIS SUBROUTINE INITIALIZES THE OS OPTIONS EXECUTIVE
C     INCLUDING THE READING OF DATA CARDS FOR TABLE AND TRACK VARIABLES
C     ,ADC AND DAC ASSIGNMENTS, AND ALL INITIAL
C     VALUES FOR INTERACTIVE VARIABLES. IT ALSO ESTABLISHES
C     COMMUNICATION INITIALIZATION WITH THE HYBRID OPERATOR'S STATION
C
C ***********************************************************************
C
C************************** COMMON AREAS ********************************
C
      COMMON/START/ ZDUMMY(4)
      COMMON/VHTPNM/ TABVAR,INDVAR,WRDVNT
      COMMON/OSTRAN/ ICT,IRT,MOPU,IRUNS,LRUNS,REALT,ITRUNS
      COMMON/DACADC/ NAMDAC,NAMADC,IDAC,IADC,ADCNUM,DACNUM
      COMMON/TABBS/ ITABP,ITABI,ITNAM,TABNUM
      COMMON/DEVICE/KEYBD,ITTY,ICDRD,LPTR,LPNT
      COMMON/OSMON/ IREALT,NNNN
      COMMON/IO/ DACPLA,ADCPLA,SCALDC,SCALAC
      COMMON/TRACK/JIN,IKEEP,ATRACK,ISAMP,ONTIM,OFFTIM,ITRA,
     1 ITRAA,ITRNA,ITRIA
      COMMON/UNREAD/NAMEA,IWRDCT,INUMCT,LSTART,INDEXA,
     1 FNUMA,LAST,ILOP
      COMMON/FIND/ORNAME(400),NCOM,RSVAL(002),IORDER(400)
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      COMMON/TIMBLK/JJTIME,TIME,DT
C
C***********************************************************************
C
      REAL*8 LMNAME
      REAL*8 VEHICL
      REAL*8 TABVAR(9,7)
      REAL*8 NAMEA(10)
      REAL*8 ORNAME
      REAL*8 ENDDAC,ENDADC
      REAL*4 ZDUMMY
      REAL*4 FNUMA(10)
      REAL*4                     SCALAC(48),SCALDC(48)
      REAL*4 IPOT,IPOTAD
      INTEGER*4 INDEXA(10)
```

```
      INTEGER*4 ITABP(9),TABNUM,ITNAM(9)
      INTEGER*4 ITABI(9)
      INTEGER*2 WRDVNT(9)
      INTEGER*2 INDVAR(9,7)
      INTEGER*2 ITRAA(50),ITRNA(50),ITRIA(50)
      INTEGER*2 DACNUM,ADCNUM,DACPLA(48),ADCPLA(48)
      INTEGER*2 NAMDAC(48),NAMADC(48),IDAC(48),IADC(48)
      EQUIVALENCE (BVALUE(1),ZDUMMY(1))
      EQUIVALENCE (BVALUE(1),IVALUE(1))
      DATA ENDDAC/'ENDNODAC'/,ENDADC/'ENDNOADC'/
      DIMENSION ATRACK(2000)
      DIMENSION BVALUE(2)
      DIMENSION IVALUE(2)
C
C **********************************************************************
C
      KEYBD=5
      ITTY=6
      ICDRD  = 1
      LAST=72
      LPTR   =2
      LPNT = 3
      CALL TYPER2(KEYBD,ITTY,LPNT)
      CALL SETUP(ITTY,ICDRD)
      IRT=0
      IKEEP=0
      JIN=0
      TABNUM=9
      MOPU=6
      LRUNS=0
      IRUNS=1
      ICT=0
      LSTART=1
      ADCNUM=48
      DACNUM=48
      ITRUNS=0
      REALT=1.
      ONTIM=1000.
      NNNN=0
C
C     THIS SECTION WRITES THE PROBLEM TITLE AND LOAD MODULE NAME
C
      WRITE(ITTY,11)
   11 FORMAT(T10,'HYBRID VEHICLE HANDLING PROGRAM')
      READ(ICDRD ,101) NUM,LMNAME,VEHICL
101   FORMAT(I3,A8,A8)
      WRITE(ITTY,201) NUM,LMNAME,VEHICL
      WRITE(LPTR,201) NUM,LMNAME,VEHICL
201   FORMAT(1H0,' HYBRID COMPUTER PROB# ',I3/A8,'  LOAD MODULE'/
     1 A8,' VEHICLE'//)
      WRITE(ITTY,301)
301   FORMAT(1H0,' ENGAGE PATCH PANEL FOR TEST')
      WRITE(ITTY,401)
401   FORMAT(1H ,' TYPE CR WHEN READY')
      READ(KEYBD,151) LL
151   FORMAT(I1)
C
C **********************************************************************
C
```

```
C#####--- THIS ROUTINE SETS UP TRACK NAME ARRAY
      ITRA=0
  130 CALL UNFORM(ICDRD,1)
      IF(IWRDCT.EQ.0) GO TO 120
      DO 110 I=1,IWRDCT
      CALL FINDNM(K,J,I,&110)
      IF(ITRA.GE.50) WRITE(ITTY,4010) ORNAME(J)
      IF(ITRA.GE.50) GO TO 110
 4010 FORMAT(1H ,'ERROR TRACK TABLE EXCEEDED,LAST NAME WAS',A6)
      ITRA=ITRA+1
      ITRAA(ITRA)=K
      ITRNA(ITRA)=J
      ITRIA(ITRA)=INDEXA(I)
  110 CONTINUE
      GO TO 130
  120 CONTINUE
C#####--- THIS ROUTINE SETS UP TABLE NAME ARRAY
      DO 10101 JJ=1,7
      CALL UNFORM(ICDRD,1)
      TABNUM=IWRDCT
      DO 102 LL=1,TABNUM
      TABVAR(LL,JJ) = NAMEA(LL)
      INDVAR(LL,JJ) = INDEXA(LL)
  102 CONTINUE
      WRDVNT(JJ) = TABNUM
10101 CONTINUE
C#####--- THIS ROUTINE SETS UP DAC NAMES & SCALING
      N = 0
  105 CALL UNFORM(ICDRD,1)
      IF(NAMEA(1).EQ.ENDDAC) GO TO 106
      IF(ILOP.NE.LAST) WRITE(ITTY,4000)
      IF(IWRDCT.NE.INUMCT) WRITE(ITTY,4002)
      DO 9007 I=1,IWRDCT
      CALL FINDNM(K,J,I,&105)
      N = N+1
      IF(N.GT.DACNUM) WRITE(ITTY,4005) NAMEA(I)
 4005 FORMAT(1H0,' ERROR *-DAC ARRAY > 48-* LAST VARIABLE WAS ',A8)
      IF(N.GT.DACNUM) GO TO 105
      NAMDAC(N) = J
      DACPLA(N) = K
      SCALDC(N) = FNUMA(I)
      IDAC(N) = INDEXA(I)
 9007 CONTINUE
      GO TO 105
  106 CONTINUE
      DACNUM = N
      IF(DACNUM.GE.48) DACNUM=48
C#####--- THIS ROUTINE SETS UP ADC NAMES & SCALING
      N = 0
  108 CALL UNFORM(ICDRD,1)
      IF(NAMEA(1).EQ.ENDADC) GO TO 109
      IF(ILOP.NE.LAST) WRITE(ITTY,4000)
      IF(IWRDCT.NE.INUMCT) WRITE(ITTY,4002)
      DO 1269 I=1,IWRDCT
      CALL FINDNM(K,J,I,&108)
      N = N+1
      IF(N.GT.ADCNUM) WRITE(ITTY,4008) NAMEA(I)
 4008 FORMAT(1H0,' ERROR *-ADC ARRAY > 48-* LAST VARIABLE WAS ',A8)
      IF(N.GT.ADCNUM) GO TO 108
```

```
      NAMADC(N) = J
      ADCPLA(N) = K
      IADC(N) = INDEXA(I)
      SCALAC(N) = FNUMA(I)
 1269 CONTINUE
      GO TO 108
  109 CONTINUE
      ADCNUM = N
      IF(ADCNUM.GE.48) ADCNUM=48
C#####--- THIS ROUTINE READS IN FLOATING POINT NAMES AND VALUES ---#####
   90 CALL UNFORM(ICDRD,1)
      IF(IWRDCT.EQ.0) GO TO 70
      IF(ILOP.NE.LAST) WRITE(ITTY,4000)
      IF(IWRDCT.NE.INUMCT) WRITE(ITTY,4002)
      DO 80 I=1,IWRDCT
      CALL FINDNM(K,J,I,&90)
      BVALUE(K) = FNUMA(I)
   80 CONTINUE
      GO TO 90
   70 CONTINUE
C#####--- THIS ROUTINE READS IN FIX POINT NAMES AND VALUES ---#####
   91 CALL UNFORM(ICDRD,1)
      IF(IWRDCT.EQ.0) GO TO 71
      IF(ILOP.NE.LAST) WRITE(ITTY,4000)
      IF(IWRDCT.NE.INUMCT) WRITE(ITTY,4002)
      DO 81 I=1,IWRDCT
      CALL FINDNM(K,J,I,&91)
      IVALUE(K) = IFIX(FNUMA(I))
   81 CONTINUE
      GO TO 91
   71 CONTINUE
 4000 FORMAT(1H0,' MAXIMUM 10 PAIRS PER DATA CARD - COLUMNS 1 THRU 72')
 4002 FORMAT(1H0,' DATA MUST BE ENTERED IN PAIRS - NAME AND VALUE')
  810 CONTINUE
C
C ***********************
C *                     *
C * INITIALIZATION PASS *
C *                     *
C ***********************
C
      DO 1701 I=1,120
      IPOT(I)=100000.
      IPOTAD(I)=100000.
 1701 CONTINUE
C
      CALL SACN(1,ISACNE)
      CALL SAMO(1,ISAMOE)
      CALL SLMO(3,ISLMOE)
      CALL SLMO(1,ISLMOE)
C
      RETURN
      END
```

H-2.1.3 USERIN

Presented here is the Fortran listing for the USERIN subprogram. The following is performed: Reading of data cards for vehicle functions and parameters.

```
C     SUBROUTINE USERIN
      SUBROUTINE USERIN
C***********************************************************************
C     THIS SUBPROGRAM READS DATA CARDS FOR VEHICLE FUNCTIONS
C     AND PARAMETERS
C***********************************************************************
      COMMON/VHTPDT/ PARMNO,VHTPAR
      COMMON/DEVICE/KEYBD,ITTY,ICDRD,LPTR,LPNT
      COMMON/APL/ OPEN   ,RTSW   ,LDTSW ,RBSW
      COMMON/SPRING/  DLSUS1,DLSUS2,DLSUS3,DLSUS4,DELSF1(10),DELSF2(10),
     1DELSR3(10),DELSR4(10),FDLSF1(10),FDLSF2(10),FDLSR3(10),FDLSR4(10),
     1NDELF1,NDELF2,NDELR3,NDELR4
      COMMON/STRFUN/ NST,STRTM(20),STEER(20)
      COMMON/AROTBS/ TAU(40),CX(40),CY(40),CZ(40),CL(40),
     1CM(40),CN(40), ALPHA(40),DELCX(40),NAERO,NDCX,
     1 XWP(20),VYWTB(20),NWP
      COMMON/NEWTBS/TQBF(20),PBF(20),TQBR(20),PBR(20),
     1AFA(20),GAMF(20),NTF,NTR,NFA
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      COMMON/SOLDAX/ PHIFNT(07),THEFNT(07),
     1       PSIFNT(7),PHIRR(7),THERR(7),PSIRR(7)
      COMMON/ALPHA/ALPH(20)
      COMMON/SHOCKS/ZDBPRF(10),ZDBPLF(10),ZDBPRR(10),ZDBPLR(10),
     1               SAFRF(10),SAFLF(10),SAFRR(10),SAFLR(10),
     2               NRF,NLF,NRR,NLR,
     3               ZETDRF,ZETDLF,ZETDRR,ZETDLR,
     4               AKSRF,AKSLF,AKSRR,AKSLR,FSARF,FSALF,FSARR,FSALR
      REAL*4 VHTPAR(27,7)
      INTEGER*4 PARMNO(27),NUMPRM/27/
      INTEGER*2 OPEN,RTSW,LDTSW,RBSW
         RBSW    = 0
         OPEN    = 0
      RTSW=1
      N1=295
      N2=119
 3333 FORMAT(20A4)
      READ(ICDRD,3333) (ALPH(I),I=1,20)
      READ(ICDRD, 900) (PHIFNT(I),I=1,7)
      READ(ICDRD, 900) (THEFNT(I),I=1,7)
      READ(ICDRD,900)  (PSIFNT(I),I=1,7)
      READ(ICDRD,900) (PHIRR(I),I=1,7)
      READ(ICDRD,900)  (THERR(I),I=1,7)
      READ(ICDRD,900) (PSIRR(I),I=1,7)
      NTF=1
  200 READ(ICDRD,900)   PBF(NTF),TQBF(NTF)
      IF(PBF(NTF).GE.99999.0)GO TO 210
      NTF=NTF+1
      GO TO 200
  210 NTF=NTF-1
      NTR=1
  220 READ(ICDRD,900)  PBR(NTR),TQBR(NTR)
      IF(PBR(NTR).GE.99999.0)GO TO 230
      NTR=NTR+1
```

```
      GO TO 220                                                          USER 430
  230 NTR=NTR-1                                                          USER 440
      NFA=1                                                              USER 450
  280 READ(ICDRD,900)GAMF(NFA),AFA(NFA)                                  USER 460
      IF(GAMF(NFA).GE.99999.0)GO TO 290                                  USER 470
      NFA=NFA+1                                                          USER 480
      GO TO 280                                                          USER 490
  290 NFA=NFA-1                                                          USER 500
      NWP=1                                                              USER1050
340   READ(ICDRD,900) XWP(NWP),VYWTB(NWP)                                USER1060
      IF(XWP(NWP).GE. 99999.) GO TO 350                                  USER1070
      NWP=NWP+1                                                          USER1080
      GO TO 340                                                          USER1090
350   NWP=NWP-1                                                          USER1100
      NAERO = 1
  240 READ(ICDRD,900) TAU(NAERO),CX(NAERO),CY(NAERO),CZ(NAERO),CL(NAERO)
     1, CM(NAERO),CN(NAERO)
      IF(TAU(NAERO).GE.99999.) GO TO 241
      NAERO = NAERO + 1
      GO TO 240                                                          USER 550
  241 NAERO = NAERO - 1
      NDCX=1                                                             USER 870
 252  READ(ICDRD,900) ALPHA(NDCX),DELCX(NDCX)                            USER 880
      IF(ALPHA(NDCX).GE.99999.) GO TO 253                                USER 890
      NDCX= NDCX+1                                                       USER 900
      GO TO 252                                                          USER 910
 253  NDCX =NDCX-1                                                       USER 920
C     READ IN STEER PROFILE DATA
      NST = 1
  360 READ(ICDRD,900) STRTM(NST),STEER(NST)
      IF(STRTM(NST).GE.99999.) GO TO 370
      NST = NST + 1
      GO TO 360
  370 NST = NST - 1
      NDELF1 = 1
  300 READ(ICDRD,900) DELSF1(NDELF1) , FDLSF1(NDELF1)
      IF(DELSF1(NDELF1).GE.99999.) GO TO 310
      NDELF1 = NDELF1 + 1
      GO TO 300
  310 NDELF1 = NDELF1 - 1
      NDELF2 = 1
  301 READ(ICDRD,900) DELSF2(NDELF2) , FDLSF2(NDELF2)
      IF(DELSF2(NDELF2).GE.99999.) GO TO 311
      NDELF2 = NDELF2 + 1
      GO TO 301
  311 NDELF2 = NDELF2 - 1
      NDELR3 = 1
  302 READ(ICDRD,900) DELSR3(NDELR3) , FDLSR3(NDELR3)
      IF(DELSR3(NDELR3).GE.99999.) GO TO 312
      NDELR3 = NDELR3 + 1
      GO TO 302
  312 NDELR3 = NDELR3 - 1
      NDELR4 = 1
  303 READ(ICDRD,900) DELSR4(NDELR4) , FDLSR4(NDELR4)
      IF(DELSR4(NDELR4).GE.99999.) GO TO 313
      NDELR4 = NDELR4 + 1
      GO TO 303
  313 NDELR4 = NDELR4 - 1
      NRF=1
 600  READ(ICDRD,900) ZDBPRF(NRF),SAFRF(NRF)
```

```
      IF(ZDBPRF(NRF).GE.99999.) GO TO 601
      NRF=NRF+1
      GO TO 600
 601  NRF=NRF-1
      NLF=1
 602  READ(ICDRD,900) ZDBPLF(NLF),SAFLF(NLF)
      IF(ZDBPLF(NLF).GE.99999.) GO TO 603
      NLF=NLF+1
      GO TO 602
603   NLF=NLF-1
      NRR=1
604   READ(ICDRD,900) ZDBPRR(NRR),SAFRR(NRR)
      IF(ZDBPRR(NRR).GE.99999.) GO TO 605
      NRR=NRR+1
      GO TO 604
605   NRR=NRR-1
      NLR=1
606   READ(ICDRD,900) ZDBPLR(NLR),SAFLR(NLR)
      IF(ZDBPLR(NLR).GE.99999.) GO TO 607
      NLR=NLR+1
      GO TO 606
607   NLR=NLR-1
 900  FORMAT(7E10.0)                                                        USER1110
      READ(ICDRD,100) (PARMNO(J),(VHTPAR(J,I),I=1,7),J=1,NUMPRM)           USER1120
 100  FORMAT(I3,1X,7F10.3)                                                  USER1130
      ENTRY USERN2                                                          USER1140
      DO 1028 I=1,500                                                       USER1150
      READ(ICDRD,50,END=32) NOPARM,PARVAL                                   USER1160
  50  FORMAT (I3,1X,G20.6)                                                  USER1170
      IF(NOPARM.EQ.304) GO TO 2222                                          USER1180
1100  PARAM(NOPARM)=PARVAI                                                  USER1190
1028  CONTINUE                                                              USER1200
32    WRITE(ITTY,33)                                                        USER1210
  33  FORMAT(' END OF CARDS')                                               USER1220
2222  CONTINUE                                                              USER1230
      RETURN                                                                USER1240
      END                                                                   USER1250
```

H-2.1.4 VHTPIC

Presented here is the Fortran Listing for the VHTP initialization subprogram. The appropriate elements of the PARAM array are initialized in VHTPIC for performance of the selected VHTP.

```
C     SUBROUTINE VHTPIC
      SUBROUTINE VHTPIC
C**********************************************************************
C     THE APPROPRIATE ELEMENTS OF THE PARAM ARRAY ARE INITIALIZED IN
C     VHTPIC FOR PERFORMANCE OF THE SELECTED VHTP MANEUVER
C**********************************************************************
      COMMON/VHTPDT/ PARMNO,VHTPAR
      COMMON/TABBS/ ITABP,ITABI,ITNAM,TABNUM
      COMMON/VHTPNM/ TABVAR,INDVAR,WRDVNT
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      COMMON/UNREAD/NAMEA,IWRDCT,INUMCT,LSTART,INDEXA,
     1 FNUMA,LAST,ILOP
      REAL*8 NAMEA(10)
      REAL*8 TABVAR(9,7)
      REAL*4 VHTPAR(27,7)
      INTEGER*4 INDEXA(10)
      INTEGER*4 PARMNO(27),NUMPRM/27/
      INTEGER*4 ITABI(9)
      INTEGER*4 ITABP(9),TABNUM,ITNAM(9)
      INTEGER*2 INDVAR(9,7)
      INTEGER*2 WRDVNT(9)
      EQUIVALENCE (SAVE,PARAM(400))
      IF(SAVE.EQ.PARAM(129)) GO TO 500
      I = IFIX(PARAM(129)) + 1
      IF(I.EQ.1) GO TO 10
      IF((I.GE.2).AND.(SAVE.NE.1)) GO TO 10
C     IF I = 1 ORIGINAL DATA MUST BE RESTORED
C     IF IIS NOT = 1 MUST DECIDE TO STORE DATA
C     IF I NE 1 AND OLD I NE 1 DO NOT STORE
      DO 20 J=1,NUMPRM
      VHTPAR(J,1) = PARAM(PARMNO(J))
   20 CONTINUE
   10 CONTINUE
      DO 30 J=1,NUMPRM
      PARAM(PARMNO(J)) = VHTPAR(J,I)
   30 CONTINUE
C     STRRAT IS THE OVERALL STEERING RATIO
      STRRAT = PARAM(42)*(PARAM(134)/PARAM(138))
      IF(PARAM(129).EQ.4) PARAM(114)= STRRAT  *((PARAM(6)+PARAM(7)))/60.
      IF(PARAM(129).EQ.5) PARAM(123)=66.*(PARAM(6)+PARAM(7))*STRRAT
     1 / (PARAM(66)*88.)
      IF(PARAM(129).EQ.6) PARAM(123)= STRRAT  *(PARAM(6)+PARAM(7))
     1 / 7.5
C     SELECTS VARIABLES FOR TABLE OUTPUT
      I=IFIX(PARAM(129))
      IF(I.EQ.0) I=7
      TABNUM = WRDVNT(I)
      DO 40  J=1,TABNUM
      NAMEA(J) = TABVAR(J,I)
      INDEXA(J) = INDVAR(J,I)
   40 CONTINUE
      DO 100 I=1,TABNUM
      CALL FINDNM(K,J,I,&100)
```

```
      ITABI(I)=INDEXA(I)
      ITNAM(I)=J
      ITABP(I)=K
  100 CONTINUE
  500 CONTINUE
      SAVE = PARAM(129)
      RETURN
      END
```

H-2.1.5 NITIAL

Presented here is the Fortran listing for the initialization subprogram. The following is performed in NITIAL:

1. Calculation of initial conditions using input data.

2. Initialization of DAC to their time = 0 values.

```
C     SUBROUTINE NITIAL
      SUBROUTINE NITIAL
C*************************************************************************
C     THIS SUBPROGRAM CALCULATES INITIAL CONDITIONS USING INPUT DATA
C     AND INITIALIZES DIGITAL-TO-ANALOG CONVERTERS TO THEIR
C     TIME=0 VALUES
C*************************************************************************
      DIMENSION NAMEX(124),NAME(289)
      COMMON/CFRC/ SL(4),SEP(4),CFCOEF(4),ARPS(4)
      COMMON/IANDG/ AIXP,AIXZP,GAM1,GAM2,GAM3,GAM4,GAM5,GAM6,
     1GAM7,GAM8,GAM9,AIYP,AIZP
      COMMON/DUALS/IDULTR,NWHEEL,TIRO2,TORO2,TIRTOR,VBRZRP,
     1 FXU5,FXU6,FYU5,FYU6,ALTQ5,ALTQ6,FSI3,FSI4,FSI5,FSI6,PPHIR
      COMMON/AERO/SFXS,SFYS,SFZS,SNTHES,SNPHIS,SNPSIS,APLUSB,IAERO
      COMMON/APL/ OPEN  ,RTSW  ,LDTSW ,RBSW
      COMMON/DEVICE/KEYBD,ITTY,ICDRD,LPTR,LPNT
      COMMON/SPLTAX/ SPSR3,SPSR4,IAX
      COMMON/HHHH/H1,H2,H3,H4
      COMMON/ZILCH/TQMAXF,TQMAXR,AKTQF,AKTQR,TQDRF,TQDRR,IDRSW
      COMMON/CACATO/EPSK1,EPSK2,FEE1,FEE2,THE1,THE2
      COMMON/THINGS/TMAX1,TMAX2,TMAX3,TQRMAX,TQFMAX,PSIMAX,ONER
      COMMON/EES/O1,O2,O3,E4,E5,E6
      COMMON/ALPHA/ALPH(20)
      COMMON/COMBLK/ SM,CIP,CIVP,RZF,RZR,A2T,CA20,CA23,TSFO2,
     1     TRO2,TFO2,TSO2,G,THRD,IWN7,R2T,RA20,RA23
      COMMON/TIMBLK/JJTIME,TIME,DT
      COMMON/EFFS/ANUM,ADEN,ANUMDT,ADENDT,ANUMO,ADENO,ANUMDO,ADENDO,
     1   ANOUT,ADOUT
      COMMON/INOUT/ IN(48),DACO(48),ISW1,ISW7,IPRT
      COMMON/UVW/VC,UIN
      COMMON/XYZ/ NUMBR
      COMMON/OPSW/IHSW
      COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      COMMON/XBS/XB(30),NS(4,30),DELX(4),XI(4),NNN
      COMMON/NONAME/XEND,O,EXIT2
      COMMON/NEWER/TIME25,TIME10,PSI5,PHIMAX,DSWMAX
      COMMON/CCMVAR/ AXAVE,CUVRAT,BETDMX,CURTBP,TIMDEC,JUMP,DELSTR,DEL,
     1               AXI,CURVAV,ABBTV,AYMAX,RMAX,DELBET,DELPSI,BETAMX,
     1               TIMBMP,GETDL,TIMIN5,        TSTEP ,    IVHTP
      COMMON/PAUL/ D1,D2,D3,D4,SFYU,TMP,SNPHIU,SNTHEU,SNPSIU,
     1QDT,PDT, RDT ,UDT,VDT,WDT,PHIDT,THEDT,PSIDT,XDT,YDT,ZDT,
     1 AKK1,AKK2,                              THS1,THS2,
     1AMT1,AMT2,SN,SFXU,BTVDT,ETAX,ETAL,
     1 ZIP(4),PHII(4),
     1       U1I(4),BAMI(4),MUP(4),SAMI(4),FI(4),FXUI(4),FYUI(4),GI(4),
     1       ALFI(4),BETIP(4),BETIBR(4),SLIPI(4),AM1I(4),AM2I(4),UOI(4),
     1       FCI(4),FCIMAX(4),FSI(4),
     1       ABI(4),BETAI(4),AMUI(4),SNI(4),RMI(4),GBI(4),FRIBR(4),
```

```
1       RWZI(4),ZI(4),FRI(4),          UI(4),VI(4),WI(4),UGI(4),            430
1       VGI(4),SINPSI(4),PSII(4),COSPSI(4),UGIP(4),PHICGI(4),CVI(4)       440
1,ALTQ(4),OTM(4),SALTQ,FOTM,ROTM                                           450
1,AP1,AP2,AP3,AP4,AR1,AR2,AR3,AR4,ANTI1,ANTI2,ANTI3,ANTI4
1,DLIS(4),ZIMX(4),FBS1,FBS2,FBS3,FBS4                                      470
1,PHIDMX                                                                   480
 COMMON/ADCOUT/ DEL1DT,DEL2DT,DEL3DT,DEL1,DEL2,DEL3,PHIRD,PHIR,
2 DELFW1,DELFW2,S1P,S2P,S3P,S4P
 COMMON/CNTROL/  EPSDSW,EPSTQR,EPDSWI,EPTQRI,ALAMDA
 COMMON/SHOCKS/ZDBPRF(10),ZDBPLF(10),ZDBPRR(10),ZDBPLR(10),
1              SAFRF(10),SAFLF(10),SAFRR(10),SAFLR(10),
2              NRF,NLF,NRR,NLR,
3              ZETDRF,ZETDLF,ZETDRR,ZETDLR,
4              AKSRF,AKSLF,AKSRR,AKSLR,FSARF,FSALF,FSARR,FSALR
 EQUIVALENCE (ARPS(1),ARPS1),(ARPS(2),ARPS2),(ARPS(3),ARPS3),
1 (ARPS(4),ARPS4)
 EQUIVALENCE                                                          NITI 390
1   (PARAM( 1),AMS)     , (PARAM( 2),AMUF)  , (PARAM( 3),AMUR)   ,  NITI 400
1   (PARAM( 4),ZF)      , (PARAM( 5),ZR)    , (PARAM( 6),A)      ,  NITI 410
1   (PARAM( 7),B)       , (PARAM( 8),TF)    , (PARAM( 9),TR)     ,  NITI 420
1   (PARAM(10),TS)      , (PARAM(11),AIX)   , (PARAM(12),AIY)    ,  NITI 430
1   (PARAM(13),AIZ)     , (PARAM(14),AIXZ)  , (PARAM(15),AIR)    ,  NITI 440
1   (PARAM(16),ROOVER)  , (PARAM(17),RF)    ,
1   (PARAM(19),AKF1)    , (PARAM(20),AKF2)  , (PARAM(21),AKR3)   ,  MODE 890
1   (PARAM(22),AKR4)    , (PARAM(23),CR)    , (PARAM(24),RR)     ,  MODE 910
1   (PARAM(25),CF1P)    , (PARAM(26),CF2P)  , (PARAM(27),CR3P)   ,  MODE 900
1   (PARAM(28),CR4P)                        , (PARAM(30),AKRS)   ,  MODE 920
1   (PARAM(31),RW)                          , (PARAM(33),OT)     ,  NITI 500
1   (PARAM(34),CA0)     , (PARAM(35),CA1)   , (PARAM(36),CA2)    ,  NITI 510
1   (PARAM(37),CA3)     , (PARAM(38),CA4)   , (PARAM(39),TIR )   ,  NITI 520
1   (PARAM(44),AKDL)    , (PARAM(41),AKSC)  , (PARAM(42),ANG)    ,  NITI 530
1   (PARAM(43),WG)      , (PARAM(40),TOR )  , (PARAM(45),AKSL)      NITI 540
 EQUIVALENCE                                                          NITI 550
1   (PARAM(46),ANL1)    , (PARAM(47),AIFW)  , (PARAM(48),AIF)    ,  NITI 560
1   (PARAM(49),AIWF)    , (PARAM(50),AIWR)  , (PARAM(51),AID)    ,  NITI 570
1   (PARAM(52),ARBR)    , (PARAM(53),TSF )  , (PARAM(54),AKFS)   ,  NITI 580
1   (PARAM(55),PTBR)    , (PARAM(56),YSA1)  , (PARAM(57),YSA2)   ,  NITI 590
1   (PARAM(58),YHS1)    , (PARAM(59),YHS2)  , (PARAM(60),AKD)    ,  NITI 600
1   (PARAM(61), AIDF)   , (PARAM(62),ARFBR) , (PARAM(63),PIN)    ,  NITI 610
1   (PARAM(64),QIN)     , (PARAM(65),RIN)   , (PARAM(66),UIZ)    ,  NITI 620
1   (PARAM(67),VIN)     , (PARAM(68),WIN)   , (PARAM(69),XIN)    ,  NITI 630
1   (PARAM(70),YIN)     , (PARAM(71),ZIN)   , (PARAM(72),THEIN)  ,  NITI 640
1   (PARAM(73),PHIIN)   , (PARAM(74),PSIIN) , (PARAM(75),DTIN)   ,  NITI 650
1   (PARAM(76),TEND)    , (PARAM(77),AKT1)  , (PARAM(78),AKT2)  ,   NITI 660
1   (PARAM(79),AKT3)    , (PARAM(80),AKT4)  , (PARAM(81),RPS1)  ,   NITI 670
1   (PARAM(82),RPS2)    , (PARAM(83),RPS3)  , (PARAM(84),RPS4)   ,  NITI 680
1   (PARAM(85),B1)      , (PARAM(86),B2)    , (PARAM(87),B3)        NITI 690
 EQUIVALENCE                                                          NITI 700
1 (PARAM(88),B4),         (PARAM( 89),DEL1DN),(PARAM( 90),DEL2DN),   NITI 710
1  (PARAM( 91),DEL3DN),(PARAM( 92),DELFIN), (PARAM( 93),DELRIN),     NITI 720
1   (PARAM( 94),DEL3IN), (PARAM( 95),PHIDN), (PARAM(96),PHIRN),      NITI 730
1   (PARAM( 97),DFW1IN), (PARAM( 98),DFW2IN),(PARAM( 99),U1PIN),     NITI 740
1   (PARAM(100),U2PIN),  (PARAM(101),U3PIN), (PARAM(102),U4PIN),     NITI 750
1   (PARAM(103),S1PIN),  (PARAM(104),S2PIN), (PARAM(105),S3PIN),     NITI 760
1   (PARAM(106),S4PIN), (PARAM(107),PPRT),(PARAM(109),RWSF)          NITI 770
1,(PARAM(110),TQMAX),(PARAM(111),AKTQ),(PARAM(112),VCIN)             NITI 780
1,(PARAM(113),SWMT),(PARAM(114),DSWCM),(PARAM(115),TST),             NITI 790
1(PARAM(116),DSLP),(PARAM(117),CGAM),(PARAM(118),CS)                 NITI 800
1  ,(PARAM(119),TQRBR),(PARAM(120),TQFBR)                            NITI 810
1  ,(PARAM(121),PFL),(PARAM(122),TTD),(PARAM(123),DSW)               NITI 820
1   ,(PARAM(124),TSW)                                                NITI 830
```

```
      EQUIVALENCE                                                       NITI 840
     1  (PARAM(130),AMCR),(PARAM(131),ESP),(PARAM(132),AKSL1),         NITI 850
     1  (PARAM(133),AKSL2),(PARAM(134),AA1),(PARAM(135),AA2),           NITI 860
     1  (PARAM(136),CCR),(PARAM(137),CFCR),(PARAM(138),AP),             NITI 870
     1  (PARAM(139),EP1),(PARAM(140),EP2),(PARAM(141),ERR1),            NITI 880
     1  (PARAM(142),ERR2),                                              NITI 890
     1  (PARAM(143),AML1),(PARAM(144),AML2),(PARAM(145),RRIM),          NITI 900
     1   (PARAM(146),RWR)                                               NITI 910
      EQUIVALENCE                                                       NITI 920
     1   (PARAM(284),HFC),(PARAM(285),HRC)                              NITI 930
      EQUIVALENCE                                                       NITI 940
     1   (PARAM(290),ROT),(PARAM(291),RA0),(PARAM(292),RA1),            NITI 950
     1   (PARAM(293),RA2),(PARAM(294),RA3),(PARAM(295),RA4)             NITI 960
      EQUIVALENCE (NAME(172),NAMEX(1))                                  NITI1080
      EQUIVALENCE (PARAM(351),IOUT(1))
      EQUIVALENCE (PHIFD,DEL2DT),(PHIF,DEL2)                            NITI1090
      EQUIVALENCE (PHIRD,DEL4DT),(PHIR,DEL4)                            NITI1100
      DATA NAME/'  MS',' MUF',' MUR','  ZF','  ZR','   A','   B','  TF',NITI1110
     1   '  TR',' TSR','  IX','  IY','  IZ',' IXZ','  IR','ROOR','  RF',NITI11
     1   'STOP','AKF1','AKF2','AKR3','AKR4',' ALS','  RR','CF1P','CF2P',NITI1130
     1   'CR3P','CR4P','ZBAS',' KRS','  RW','SCAL',' FOT','  A0','  A1',NITI1140
     1   '  A2','  A3','  A4','TIR ','TOR ',' KSC','  NG',' TSD','DSLM',NITI1150
     1   ' TFT','DSW2',' IFW',' IF ',' IWF',' IWR',' IDR',' ARR','TSF ',NITI1160
     1   'KFS ','  PT','YSA1','YSA2','PHS1','PHS2','CTSW',' IDF',' ARF',NITI1170
     1   'P-IN','Q-IN','R-IN','U-IN','V-IN','W-IN','X-IN','Y-IN','Z-IN',NITI1180
     1   'THIN','PHIN','PSIN','  DT','  TN',' KT1',' KT2',' KT3',' KT4',NITI1190
     1   'RPS1','RPS2','RPS3','RPS4','  B1','  B2','  B3','  B4','D1DT',NITI1200
     1   'D2DT','D3DT','DELF','DELR','DEL3','PHDT','PHIR','DFW1','DFW2',NITI1210
     1   'U1PR','U2PR','U3PR','U4PR','S1PR','S2PR','S3PR','S4PR','PPRT',NITI1220
     1   'FREQ','    ','TQMX',' KTQ','  VC','MTSW','DSWM',' TST','DSLP',NITI1230
     1   'CGAM','  CS',' TQR',' TQF',' PFL',' TTD','DSW1','    ','ISW5',NITI1240
     1   'SW15',                                                        NITI1250
     1   '    ','VTPS','VHTP','AMCR',' ESP','KSL1','KSL2',' AA1',' AA2',NITI1260
     1   ' CCR','CFCR','  AP',' EP1',' EP2','AERO','VYW ','OMXW','OMZW',NITI1270
     1   'RHOA','CYP ','CYR ','CZAL','CZQ ','CLP ','CLR ','CMAL','CMQ ',NITI1280
     1   'CNP ','CNR ','SF  ','VLEN','REWV','    ','    ','    ','    ',NITI1290
     1   '    ','    ','    ','    ','    ','    ',' SNT','SNSO','SNS1'/NITI1300
      DATA NAMEX                                                        NITI1310
     1  /'SNSW','DIST',' PL ','TSCP','SCSW','    ','    ','    ','    ',NITI1320
     1   '    ',' SI1',' SI2',' SI3',' SI4','SARF','SALF','SARR',       NITI1330
     1   'SALR','    ','    ','MTQB','DCSW',' LDF','LDRF',' EK1',' EK2',NITI1340
     1   'BMPL','BMPS','BMPH','  XB','APF1','APF2','APR1','APR2','MUSF',NITI1350
     1   'MUSR','BCON','FCSW','S1F ','S1R ','KLR ','KOTF','KOTR','    ',NITI136
     1   '    ','    ','    ','FEE1','FEE2','THE1','THE2','ALMC','    ',NITI1370
     1   '    ','    ','    ','    ','    ','    ','  H1','  H2','LAMD',NITI1380
     1   '    ','    ','PS01','PS02',' BR1',' BR2',' BR3',' BR4',       NITI1390
     1   ' KCF',' KCR',' KSR',' RB1',' RB2',' RB3',' RB4','AFK1','AFK2',NITI1400
     1   'AFK3','ARK1','ARK2','ARK3','OFC0','OFC1','OFC2','OFC3','ORC0',NITI1410
     1   'ORC1','ORC2','ORC3','CPOF','CP1F','CP2F','CPOR','CP1R','CP2R',NITI1420
     1   'CROF','CR1F','CR2F','CROR','CR1R','CR2R','STSW','MMSW','BMPN',NITI143
     1   'TQB0','TQB1','    ','    ','    ','    ',' HFC',' HRC','DRSW',NITI1440
     1   'AXLE','DUAL','TIRE','ROT','RA0','RA1','RA2','RA3','RA4'/      NITI1450
      EQUIVALENCE (COMPVR(1),AXAVE)                                     NITI1460
      DIMENSION COMPVR(17)                                              NITI1470
      DATA RAD/0.1745329E-1/                                            NITI1480
      DATA MPHIPS/17.6/                                                 NITI1490
      REAL*4 MPHIPS                                                     NITI1500
      REAL*4 IOUT(48),IN,    SCALAC(48),SCALDC(48)
      INTEGER*2  RTSW  ,RBSW  ,LDTSW ,OPEN  ,OPDN                       NITI1520
  960 FORMAT('1  PARAMETER VALUES - MODEL C - ',20A4,/                  NITI1530
     1   (' ',5(I4,3X,A4,'=',G12.5,',')))                               NITI1540
```

```
C     VHTP COMPARISON VARIABLE INITIALIZATION                             NITI1550
      DO 21 I=1,19                                                        NITI1560
      COMPVR(I) = 0.                                                      NITI1570
  21  CONTINUE                                                            NITI1580
      TSTEP = DTIN                                                        NITI1590
      NUMBR = 0                                                           NITI1600
      DO 20 I=1,4                                                         NITI1610
      DELX(I) = 0.                                                        NITI1620
   20 CONTINUE                                                            NITI1630
      IVHTP = PARAM(129) + .5                                             NITI1640
      IAERO = PARAM(141) + 0.5                                            NITI1650
      IDRSW = PARAM(286) + 0.5                                            NITI1660
      IAX=PARAM(287)+0.5                                                  NITI1670
C     DUAL TIRES ON SOLID REAR AXLE                                       NITI1680
C                    IDULTR = 0, NO DUALS                                 NITI1690
C                           = 1, DUALS                                    NITI1700
      IDULTR = PARAM(288) + 0.5                                           NITI1710
C     NWHEEL = 4, SINGLE REAR TIRES                                       NITI1720
C            = 6, DUAL REAR TIRES                                         NITI1730
C            = 10, DOUBLE DUAL REAR TIRES                                 NITI1740
      NWHEEL = PARAM(289) + 0.5                                           NITI1750
      AKSRF=PARAM(186)
      AKSLF=PARAM(187)
      AKSRR=PARAM(188)
      AKSLR=PARAM(189)
      TQFMAX=-1.E20                                                       NITI1760
      TQRMAX=-1.E20                                                       NITI1770
      BTVMAX=-1.E20                                                       NITI1840
      EPSK1=PARAM(196)*RAD                                                NITI1860
      EPSK2=PARAM(197)*RAD                                                NITI1870
      FEE1=PARAM(219)*RAD                                                 NITI1880
      FEE2=PARAM(220)*RAD                                                 NITI1890
      THE1=PARAM(221)*RAD                                                 NITI1900
      THE2=PARAM(222)*RAD                                                 NITI1910
      PSIMAX=-1.E20                                                       NITI1920
      PSIM=PSIIN*RAD                                                      NITI1930
      XEND=TEND                                                           NITI1940
      EXIT2 = PARAM(18)*MPHIPS
      TIME25=0.0                                                          NITI1960
      TIME10=0.0                                                          NITI1970
      ANUMO=0.0                                                           NITI2040
      ADENO=0.0                                                           NITI2050
      RMAX=-1.E20                                                         NITI2060
      PSI5=0.0                                                            NITI2070
      DSWMAX=-1.E20                                                       NITI2080
      PHIMAX=-1.E20                                                       NITI2090
      ETAMAX=-1.E20                                                       NITI2100
      ISW7=1                                                              NITI2110
      THRD=1.0/3.0                                                        NITI2120
      TWN7=1.0/27.0                                                       NITI2130
      TOO=0.0                                                             NITI2140
      G=386.4                                                             NITI2150
      APLUSB = A + B                                                      NITI2160
      H1=RW-(AMUF+B*AMS/(A+B))*G/(2.*AKT1)                                NITI2170
      H2=RW-(AMUF+B*AMS/(A+B))*G/(2.*AKT2)                                NITI2180
      H3=RW-(AMUR+A*AMS/(A+B))*G/(2.*AKT3)                                NITI2190
      H4=RW-(AMUR+A*AMS/(A+B))*G/(2.*AKT4)                                NITI2200
      IF(IDULTR.NE.1) GO TO 25                                            NITI2210
      H3 = RW - (AMUR+A*AMS /(A+B))*G/(4.*AKT3)                           NITI2220
      H4 = H3                                                             NITI2230
```

```
25   CONTINUE                                                            NITI2240
      RWZ1A = RW - H1
      RWZ2A = RW - H2
      RWZ3A = RW - H3
      RWZ4A = RW - H4
     TSO2=TS/2.0                                                         NITI2250
     TSFO2 = TSF/2.                                                      NITI2260
     TFO2=TF*0.5                                                         NITI2270
     TIRO2 = TIR/2.                                                      NITI2280
     TORO2 = TOR/2.                                                      NITI2290
     TRO2=TR*0.5                                                         NITI2300
     IF(IDULTR.EQ.1) TRO2 = (TORC2+TIRO2)*0.5                            NITI2310
     TIRTOR= 0.25*(TIR-TOR)                                              NITI2320
     SPSR3=(TAN(2.0*HFC/TF))*2.0/AMUF                                    NITI2330
     SPSR4=(TAN(2.0*HRC/TR))*2.0/AMUR                                    NITI2340
     SM=AMS+AMUF+AMUR                                                    NITI2350
     UIN=UIZ*MPHIPS                                                      NITI2360
     VC=VCIN*MPHIPS                                                      NITI2370
     ZIN=(B*(H1+ZF)+A*(H3+ZR))/(A+B)*(-1.) + PARAM(29)
     THEIN=(H1-H3+ZF-ZR)/(A+B)/RAD                                       NITI2390
     ARPS1 = UIN/H1
     ARPS2 = UIN/H2
     ARPS3 = UIN/H3                                                      NITI2400
     ARPS4 = UIN/H4                                                      NITI2410
     GO TO (31,32),IAX                                                   NITI2440
  30 AIZP = AMUF*A*A + AMUR*B*B + AIF + AIR                              NITI2450
     GO TO 33                                                            NITI2460
  31 AIZP = AMUF*(A*A + TFO2**2) + AMUR*B*B + AIR                        NITI2470
     GO TO 33                                                            NITI2480
  32 AIZP = AMUF*(A*A + TFO2**2) + AMUR*(B*B + TRO2**2)                  NITI2490
  33 CONTINUE                                                            NITI2500
     GAM1=AMUF*A-AMUR*B                                                  NITI2520
     AIZBR=AIZP +AIZ                                                     NITI2570
     CIP=B*AMS*G/(AMUF*(A+B))+G                                          NITI2680
     CIVP=A*AMS*G/(AMUR*(A+B))+G                                         NITI2690
     TQMAXR=TQMAX*ARBR*0.5                                               NITI2700
     TQMAXF=TQMAX*ARFBR*0.5                                              NITI2710
     AKTQR=AKTQ*ARBR*0.5                                                 NITI2720
     AKTQF=AKTQ*ARFBR*0.5                                                NITI2730
     RZF=RW+ZF                                                           NITI2740
     RZR=RW+ZR                                                           NITI2750
     CA23=CA2*CA3                                                        NITI2760
     A2T= OT*CA2                                                         NITI2770
     CA20=CA0*CA2                                                        NITI2780
     RA23=RA2*RA3                                                        NITI2790
     R2T=ROT*RA2                                                         NITI2800
     RA20=RA0*RA2                                                        NITI2810
     DEL1DT=DEL1DN                                                       NITI2880
     DEL2DT=DEL2DN                                                       NITI2890
     DEL3DT=DEL3DN                                                       NITI2900
     DEL1=0.0                                                            NITI2910
     DEL2=0.0                                                            NITI2920
     DEL3=DEL3IN                                                         NITI2930
     PHIRD=PHIDN*RAD                                                     NITI2940
     PHIR=PHIRN*RAD                                                      NITI2950
     DELFW1=DFW1IN*RAD                                                   NITI2960
     DELFW2=DFW2IN*RAD                                                   NITI2970
     U1P=U1PIN                                                           NITI2980
     U2P=U2PIN                                                           NITI2990
     U3P=U3PIN                                                           NITI3000
```

```
      U4P=U4PIN
      S1P=S1PIN
      S2P=S2PIN
      S3P=S3PIN
      S4P=S4PIN
      P=PIN*RAD
      Q=QIN*RAD
      R=RIN*RAD
      U=UIN
      V=VIN
      W=WIN
      X=XIN
      Y=YIN
      Z=ZIN
      THE=THEIN*RAD
      PHI=PHIIN*RAD
      PSI=PSIIN*RAD
      UDT=0.0
      VDT=0.0
      WDT =0.
      PDT =0.
      QDT =0.
      RDT=0.0
      THEDT =0.
      PHIDT = 0.
      PSIDT =0.
      BTVDT =0.
      XDT =0.
      YDT =0.
      ZDT =0.
      ZETDRF=0.0
      ZETDLF=0.0
      ZETDRR=0.0
      ZETDLR=0.0
      EPDSWI = 0.
      EPTQRI = 0.
      TIME=0.0
      JJTIME=0
      DT=0.0
  998 FORMAT('0',8E15.6)
      IHSW=0
      XB(1)=PARAM(201)
      NBMP=PARAM(277)+0.5
      IF(NBMP.LT.2)GO TO 4321
      DO 5432 I=2,NBMP
      XB(I)=XB(I-1)+PARAM(199)
 5432 CONTINUE
 4321 CONTINUE
              CALL SSRM(11,IRLERR)
      RETURN
      ENTRY NTIAL1
      CALL LBDAFP(00,47,DACO,ILBERR)
      CALL TLDA
      CALL STCO(0,ISTCOE)
      DT=DTIN
      ISW1=0
      ISW7=0
      IF(PPRT.NE.0.0) WRITE(LPTR,960) (ALPH(I),I=1,20),((K,NAME(K),
     1 PARAM(K)),K=1,N1)
  940 FORMAT(10G12.5)
      RETURN
      END
```

H-2.1.6 POTSET

Presented here is the Fortran listing for the potentiometer setting calculation subprogram. The following is performed in POTSET:

1. Calculation of parameters used in the potentiometer equations.

2. Calculation of potentiometer settings.

```
C     SUBROUTINE POTSET
      SUBROUTINE POTSET
C***********************************************************************
C     THIS SUBPROGRAM CALCULATES PARAMETERS USED IN THE POTENTIOMETER
C     EQUATIONS AND POTENTIOMETER SETTINGS
C***********************************************************************
      COMMON/DUALS/IDULTR,NWHEEL,TIRO2,TORO2,TIRTOR,VBRZRP,
     1 FXU5,FXU6,FYU5,FYU6,ALTQ5,ALTQ6,FSI3,FSI4,FSI5,FSI6,PPHIR
      COMMON/ZILCH/TQMAXF,TQMAXR,AKTQF,AKTQR,TQDRF,TQDRR,IDRSW
      COMMON/DEVICE/KEYBD,ITTY,ICDRD,LPTR,LPNT
      COMMON/HHHH/H1,H2,H3,H4
      COMMON/SPLTAX/ SPSR3,SPSR4,IAX
      COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI
      COMMON/EFFS/ANUM,ADEN,ANUMDT,ADENDT,ANUMO,ADENO,ANUMDO,ADENDO,
     1   ANOUT,ADOUT
      COMMON/COMBLK/ SM,CIP,CIVP,RZF,RZR,A2T,CA20,CA23,TSFO2,
     1      TRO2,TFO2,TSO2,G,THRD,TWN7,R2T,RA20,RA23
      COMMON/TIMBLK/JJTIME,TIME,DT
      COMMON/UVW/VC,UIN
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      COMMON/ADCOUT/ DEL1DT,DEL2DT,DEL3DT,DEL1,DEL2,DEL3,PHIRD,PHIR,
     2 DELFW1,DELFW2,S1P,S2P,S3P,S4P
      REAL*4 IOUT(48)
      REAL*4 IPOT,IPOTAD
      EQUIVALENCE
     1   (PARAM( 1),AMS)      , (PARAM( 2),AMUF)   , (PARAM( 3),AMUR)    ,
     1   (PARAM( 4),ZF)       , (PARAM( 5),ZR)     , (PARAM( 6),A)       ,
     1   (PARAM( 7),B)        , (PARAM( 8),TF)     , (PARAM( 9),TR)      ,
     1   (PARAM(10),TS)       , (PARAM(11),AIX)    , (PARAM(12),AIY)     ,
     1   (PARAM(13),AIZ)      , (PARAM(14),AIXZ)   , (PARAM(15),AIR)     ,
     1   (PARAM(16),CF)       , (PARAM(17),RF)     ,
     1   (PARAM(19),AKF1)     , (PARAM(20),AKF2)   , (PARAM(21),AKR3)    ,
     1   (PARAM(22),AKR4)     , (PARAM(23),CR)     , (PARAM(24),RR)      ,
     1   (PARAM(25),CF1P)     , (PARAM(26),CF2P)   , (PARAM(27),CR3P)    ,
     1   (PARAM(28),CR4P)                          , (PARAM(30),AKRS)    ,
     1   (PARAM(31),RW)       , (PARAM(32),SCALE)  , (PARAM(33),OT)      ,
     1   (PARAM(34),CA0)      , (PARAM(35),CA1)    , (PARAM(36),CA2)     ,
     1   (PARAM(37),CA3)      , (PARAM(38),CA4)    , (PARAM(39),TIR )    ,
     1   (PARAM(44),AKDL)     , (PARAM(41),AKSC)   , (PARAM(42),ANG)     ,
     1   (PARAM(43),WG)       , (PARAM(40),TOR )   , (PARAM(45),AKSL)
      EQUIVALENCE
     1   (PARAM(46),ANL1)     , (PARAM(47),AIFW)   , (PARAM(48),AIF)     ,
     1   (PARAM(49),AIWF)     , (PARAM(50),AIWR)   , (PARAM(51),AID)     ,
     1   (PARAM(52),ARBR)     , (PARAM(53),TSF )   , (PARAM(54),AKFS)    ,
     1   (PARAM(55),PTBR)     , (PARAM(56),YSA1)   , (PARAM(57),YSA2)    ,
```

```
1    (PARAM(58),YHS1)    , (PARAM(59),YHS2)   , (PARAM(60),AKD)     ,   POTS 450
1    (PARAM(61), AIDF)   , (PARAM(62),ARFBR)  , (PARAM(63),PIN)     ,   POTS 460
1    (PARAM(64),QIN)     , (PARAM(65),RIN)    , (PARAM(66),UIZ)     ,   POTS 470
1    (PARAM(67),VIN)     , (PARAM(68),WIN)    , (PARAM(69),XIN)     ,   POTS 480
1    (PARAM(70),YIN)     , (PARAM(71),ZIN)    , (PARAM(72),THEIN)   ,   POTS 490
1    (PARAM(73),PHIIN)   , (PARAM(74),PSIIN)  , (PARAM(75),DTIN)    ,   POTS 500
1    (PARAM(76),TEND)    , (PARAM(77),AKT1)   , (PARAM(78),AKT2)   ,    POTS 510
1    (PARAM(79),AKT3)    , (PARAM(80),AKT4)   , (PARAM(81),RPS1)   ,    POTS 520
1    (PARAM(82),RPS2)    , (PARAM(83),RPS3)   , (PARAM(84),RPS4)    ,   POTS 530
1    (PARAM(85),B1)      , (PARAM(86),B2)     , (PARAM(87),B3)          POTS 540
 EQUIVALENCE                                                            POTS 550
1 (PARAM(88),B4),          (PARAM( 89),DEL1DN),(PARAM( 90),DEL2DN),     POTS 560
1  (PARAM( 91),DEL3DN),(PARAM( 92),DELFIN), (PARAM( 93),DELRIN),        POTS 570
1    (PARAM( 94),DEL3IN), (PARAM( 95),PHIDN), (PARAM(96),PHIRN),        POTS 580
1    (PARAM( 97),DFW1IN), (PARAM( 98),DFW2IN),(PARAM( 99),U1PIN),       POTS 590
1    (PARAM(100),U2PIN),  (PARAM(101),U3PIN), (PARAM(102),U4PIN),       POTS 600
1    (PARAM(103),S1PIN),  (PARAM(104),S2PIN), (PARAM(105),S3PIN),       POTS 610
1    (PARAM(106),S4PIN), (PARAM(107),PPRT),(PARAM(109),RWSF)            POTS 620
1,(PARAM(110),TQMAX),(PARAM(111),AKTQ),(PARAM(112),VCIN)                POTS 630
1,(PARAM(113),SWMT),(PARAM(114),DSWCM),(PARAM(115),TST),                POTS 640
1(PARAM(116),DSLP),(PARAM(117),CGAM),(PARAM(118),CS)                    POTS 650
1  ,(PARAM(119),TQRBR),(PARAM(120),TQFBR)                               POTS 660
1  ,(PARAM(121),PFL),(PARAM(122),TTD),(PARAM(123),DSW)                  POTS 670
1    ,(PARAM(124),TSW)                                                  POTS 680
 EQUIVALENCE                                                            POTS 690
1   (PARAM(130),AMCR),(PARAM(131),ESP),(PARAM(132),AKSL1),              POTS 700
1   (PARAM(133),AKSL2),(PARAM(134),AA1),(PARAM(135),AA2),               POTS 710
1   (PARAM(136),CCR),(PARAM(137),CFCR),(PARAM(138),AP),                 POTS 720
1   (PARAM(139),EP1),(PARAM(140),EP2),(PARAM(141),ERR1),                POTS 730
1   (PARAM(142),ERR2),                                                  POTS 740
1   (PARAM(143),AML1),(PARAM(144),AML2),(PARAM(145),RRIM),              POTS 750
1    (PARAM(146),RWR)                                                   POTS 760
 EQUIVALENCE                                                            POTS 770
1    (PARAM(223),CR1C),(PARAM(224),CR1T),(PARAM(225),CR2C),             POTS 780
1    (PARAM(226),CR2T),(PARAM(227),CR3C),(PARAM(228),CR3T),             POTS 790
1    (PARAM(229),CR4C),(PARAM(230),CR4T),(PARAM(231),AH1),              POTS 800
1    (PARAM(232),AH2),(PARAM(233),ALAMBD)
 EQUIVALENCE                                                            POTS 830
1    (PARAM(284),HFC),(PARAM(285),HRC)                                  POTS 840
 EQUIVALENCE                                                            POTS 850
1    (PARAM(290),ROT),(PARAM(291),RA0),(PARAM(292),RA1),                POTS 860
1    (PARAM(293),RA2),(PARAM(294),RA3),(PARAM(295),RA4)                 POTS 870
 EQUIVALENCE (PARAM(351),IOUT(1))
C     N1 , N2 EQUATED TO THEIR VALUES IN MAIN                           POTS1000
 HUN=0.01                                                               POTS1010
 TOU=0.001                                                              POTS1020
 AIBR=AIWR+AID*ARBR**2*0.25                                             POTS1030
 AIBRP=AIBR-AIWR                                                        POTS1040
 AIFBR = AIWF + AIDF*ARFBR*2 * 0.25                                     POTS1050
 AIFBRP = AIFBR - AIWF                                                  POTS1060
 RPS1=UIN/H1                                                            POTS1070
 RPS2=UIN/H2                                                            POTS1080
 RPS3=UIN/H3                                                            POTS1090
 RPS4=UIN/H4                                                            POTS1100
 CALL SSRM(01,IRLERR)                                                   POTS1880
 IF(RF.GE.0) CALL SSRP(01,IRLERR)                                       POTS1890
 CALL SSRM(08,IRLERR)                                                   POTS1920
 IF(RR.GE.0) CALL SSRP(08,IRLERR)
 CALL SSRM(13,IRLERR)
```

```
IF(THE.GE.0.) CALL SSRE(13,IRLERR)
SFSF=SCALE/10000.
IPOT(01)=.2
IPOT(02)=G/400.
IPOT(05)=U/1200.
IPOT(06)=.25*PARAM(175)
IPOT(07)=2./3.*PARAM(175)
IPOT(08)=.6*PARAM(175)
IPOT(09) = .7
IPOT(12)=PARAM(175)* .15
IPOT(13)=.4
IPOT(14)=.5*PARAM(175)
IPOT(16)=TOU*CF1P*.1
IPOT(17)=.2*PARAM(175)
IPOT(19)=.2*TOU*CF1P
IPOT(20)= 4.*(ABS(THE))
IPOT(21)=.3*PARAM(175)
IPOT(22)=TOU*CF2P*.1
IPOT(23)=PSI/4.
IPOT(24)=.2*TOU*CF2P
IPOT(27)=TOU*CR3P*.1
IPOT(28)= .5*PARAM(175)
IPOT(29)=.2*TOU*CR3P
IPOT(38)=HUN*PARAM(175)*4.
IPOT(49)=TOU*CR4P*.1
IPOT(50)=AIBRP/AIBR
IPOT(51)=PARAM(175)
IPOT(52)=.2*PARAM(175)
IPOT(54)=.2*TOU*CR4P
IPOT(55)=.2
IPOT(57)=PARAM(175)
IPOT(58)=8.*A/2000.
IPOT(60)=100./AKF1
IPOT(61)=100.*AMS/SCALE
IPOT(62)=100./AKR3
IPOT(63)=SFSF
IPOT(64)=SFSF
IPOT(65)=SFSF
IPOT(68)=100./AKR4
IPOT(69)=SFSF
IPOT(72)=57.3/(1.5*200.)
IPOT(73)=PARAM(175)
IPOT(77)=HUN*PARAM(175)*4.
IPOT(78)=8.*B/2000.
IPOT(79)=57.3/(4.*200.)
IPOT(84)=.2*PARAM(175)
IPOT(85)=PARAM(175)
IPOT(87)=IPOT(57)
IPOT(88)=10./A
IPOT(89)=10./B
IPOT(90)=0.
IPOT(91)=0.
IPOT(96)=1./(1.6*11.*PARAM(175))
IPOT(100)=PARAM(175)
IPOT(101)=HUN*RPS1
IPOT(103)=TOU*G
IPOT(104)=.96
IPOT(105)=PARAM(175)
IPOT(106)= 100./AKF2
IPOT(108)=.3*PARAM(175)
IPOT(110)=HUN*RPS3
```

```
      IPOT(111)=.8
      IPOT(112)=.08
      IPOT(113)=G*TOU
      IPOT(114)=.15
      IPOT(115)=.48
      IPOT(117)=.2
      IPOT(118)=G*TOU
      IPOT(119)=IPOT(50)
C******* SPLIT FRONT AXLE LOGIC FCR 680  *****
      CALL SSCL(02,IRLERR)
             CALL  SSRM(00,IRLERR)
             CALL  SSRP(03,IRLERR)
             CALL  SSRP(07,IRLERR)
      IPOT(03)=ZF*TOU*PARAM(175)*4.
      IPOT(04) = (HUN*(ABS(RF))/(TF*TF))*.1
      IPOT(18)=20./TF
      IPOT(31)=2.*SCALE*PARAM(175)/(10000.*AMUF)
      IPOT(32)=0.
      IPOT(33)=8.*TF/4000.*PARAM(175)*2.
      IPOT(34)=0.0
      IPOT(37)=HUN*PARAM(175)*4.
      IPOT(39)=0.
      IPOT(41)=IPOT(03)
      IPOT(43)=8.*TF*PARAM(175)/4000.*2.
      IPOT(44)=0.
      IPOT(47)=0.
      IPOT(48)=2.*SCALE*PARAM(175)/(10000.*AMUF)
      IPOT(56)=0.
      IPOT(59)=0.
      IPOT(66)=0.
      IPOT(67)=0.
      IPOT(70)=.2*PARAM(175)
      IPOT(74)=PARAM(175)
      IPOT(76)=PARAM(175)
      IPOT(107)=.9999
      IPOT(109)=.9999
      IPOT(116)=.9999
      IF(IAX.NE.0) GO TO 1024
C **** SOLID FRONT AXLE LOGIC FOR 680 *****
C     CONTROL LINE #02 USED WITH INTEGRATOR A70
      CALL RSCL(02,IRLERR)
             CALL  SSRP(00,IRLERR)
             CALL  SSRM(03,IRLERR)
             CALL  SSRM(07,IRLERR)
      IPOT(03)=0.
      IPOT(04)=0.0
      IPOT(18)=20./TSF
      IPOT(31)=TSFO2*SCALE*PARAM(175)/(100.*AIF)
      IPOT(32)=TSFO2*SCALE*PARAM(175)/(100.*AIF)
      IPOT(33)=0.0
      IPOT(34)=.4*PARAM(175)*2.
      IPOT(37)=.25*PARAM(175)/10.*16.
      IPOT(39)=.25*(ABS(RF))/(10000.*TSF)*4.
      IPOT(41)=ZF*TOU*PARAM(175)*4.
      IPOT(43)=0.
      IPOT(44)=IPOT(39)
      IPOT(47)=HUN*TSFO2
      IPOT(48)=SCALE*PARAM(175)/(10000.*AMUF)
      IPOT(56)=SCALE*PARAM(175)/(10000.*AMUF)
      IPOT(59)=IPOT(47)
```

```
      IPOT(66) = TSFO2*.01
      IPOT(67)=IPOT(66)
      IPOT(70)=0.
      IPOT(74)=0.
      IPOT(76)=PARAM(175)
      IPOT(107)=0.
      IPOT(109)=0.
      IPOT(116)=0.
 1024 CONTINUE
      IF(IAX.EQ.2) GO TO 1021
C *****SOLID REAR AXLE LOGIC FOR 680  *******
C     CONTROL LINE #01  USED WITH INTEGRATOR A95
      CALL RSCL(01,IRLERR)
            CALL  SSRM(09,IRLERR)
            CALL  SSRP(10,IRLERR)
            CALL  SSRM(14,IRLERR)
      IPOT(26)=(ABS(RR)/TS)*.0001
      IPOT(30)=20./TS
      IPOT(35)=(HUN*TSO2)
      IPOT(36)=(TSO2)*.01
      IPOT(42)=PARAM(175)
      IPOT(45)=IPOT(36)
      IPOT(46)=IPOT(35)
      IPOT(53)=IPOT(26)
      IPOT(71)=0.
      IPOT(80)=ZR*TOU*PARAM(175)*4.
      IPOT(81)=SCALE*PARAM(175)/(10000.*AMUR)
      IPOT(82)=0.
      IPOT(83)=SCALE*PARAM(175)/(10COC.*AMUR)
      IPOT(92)=0.0
      IPOT(93)=TSO2*SCALE*PARAM(175)/(100.*AIR)
      IPOT(94)=TSO2*SCALE*PARAM(175)/(100.*AIR)
      IPOT(95)=.4*PARAM(175)*2.
      IPOT(97)=0.0
      IPOT(98)=0.0
      IPOT(99)=0.0
      IPOT(102)=.05*PARAM(175)*8.
      IF(IAX.EQ.0) GO TO 1028
      IPOT(107)=.9999
      IPOT(109)=.9999
      IPOT(116)=.9999
 1028 CONTINUE
      GO TO 1022
 1021 CONTINUE
C *****  SPLIT REAR AXLE LOGIC FOR 680 ******
      CALL SSCL(01,IRLERR)
            CALL  SSRM(10,IRLERR)
            CALL  SSRP(09,IRLERR)
            CALL SSRP(14,IRLERR)
      IPOT(26)=0.
      IPOT(30)=20./TR
      IPOT(35)=0.
      IPOT(36)=0.
      IPOT(42)=PARAM(175)
      IPOT(45)=0.
      IPOT(46)=0.
      IPOT(53)=0.
      IPOT(71)=(ABS(RR))/(1000.*TR**2)
      IPOT(80)=ZR*TOU*PARAM(175)*4.
      IPOT(81)=0.0
```

```
      IPOT(82)=8.*TR*PARAM(175)/4000.*2.
      IPOT(83)=2.*SCALE*PARAM(175)/(10000.*AMUR)
      IPOT(92)=IPOT(80)
      IPOT(93)=2.*SCALE*PARAM(175)/(10000.*AMUR)
      IPOT(94)=0.
      IPOT(95)=0.0
      IPOT(97)=8.*TR/4000.*PARAM(175)*2.
      IPOT(98)=PARAM(175)
      IPOT(99)=.2*PARAM(175)
      IPOT(102)=HUN*PARAM(175)*4.
      IPOT(107)=.9999
      IPOT(109)=.9999
      IPOT(116)=.9999
 1022 CONTINUE
C ***   IDRSW=0, REAR WHEEL DRIVE
C **** IDRSW=1, FOUR WHEEL DRIVE
      IF(IDRSW.NE.1) GO TO 1025
      IPOT(90)=AIFBRP/AIFBR
      IPOT(91)=IPOT(90)
 1025 CONTINUE
C     FOUR WHEEL IND SUSPENSION
      COMCON = PARAM(175)**2*(.008+.5*PARAM(75)/PARAM(175))/100.
      IPOT(10) =  (PARAM(77)/PARAM(2))*COMCON*PARAM(176)*2.
      IPOT(11) =  (PARAM(78)/PARAM(2))*COMCON*PARAM(176)*2.*0.5
      IPOT(15) =  (PARAM(79)/PARAM(3))*COMCON*PARAM(176)*2.
      IPOT(25) =  (PARAM(80)/PARAM(3))*COMCON*PARAM(176)*2.*0.5
      IF(IAX.EQ.2) GO TO 500
C     IND FRONT, SOLID REAR
      IPOT(15) =  ((PARAM(79)+PARAM(80))/PARAM(3))*COMCON*PARAM(176)
      IPOT(25) =  ((PARAM(79)+PARAM(80))*TRO2**2*COMCON*PARAM(176))
     1 /PARAM(15)*5.
      IF(IAX.EQ.1) GO TO 500
C     SOLID FRONT AND REAR
      IPOT(10) =  ((PARAM(77)+PARAM(78))/PARAM(2))*COMCON*PARAM(176)
      IPOT(11) =  ((PARAM(77)+PARAM(78))*TFO2**2*COMCON*PARAM(176))
     1 /PARAM(48)*5.
  500 CONTINUE
      RETURN
      END
```

H-2.1.7 MODEL

Presented here is the Fortran listing for the mathematical model subprogram. The following is performed in MODEL:

1. Reading of the ADC variables.

2. Computation of simulation time.

3. Calculation of digital model equations.

4. Data preparation for output of the DAC variables.

5. Detection, limiting, and flagging of ADC and DAC variable overloads.

6. Collection of TRACK data for output at the end of a run.

```
C     SUBROUTINE MODEL
      SUBROUTINE MODEL
C***********************************************************************
C     THIS SUBPROGRAM PERFORMS THE FOLLOWING :
C        1) READING OF THE ANALOG-TO-DIGITAL(ADC) CONVERTER VARIABLES
C        2) COMPUTION OF SIMULATICN TIME
C        3) CALCULATION OF DIGITAL MODEL EQUATIONS
C        4) DATA PREPARATION FOR OUTPUT ON THE DIGITAL-TO-ANALOG(D/A)
C           CONVERTERS
C        5) DETECTION, LIMITING, AND FLAGGING OF ADC AND D/A VARIABLE
C           OVERLOADS
C     6) COLLECTION OF TRACK DATA FOR OUTPUT AT THE END OF RUN
C***********************************************************************
      COMMON/START/ ZDUMMY(4)
      COMMON/IANDG/ AIXP,AIXZP,GAM1,GAM2,GAM3,GAM4,GAM5,GAM6,
     1GAM7,GAM8,GAM9,AIYP,AIZP
      COMMON/CFRC/ SL(4),SEP(4),CFCOEF(4),ARPS(4)
      COMMON/TOM/ COSABG(3,4),COABGH(3,4),COSAC(4),COSBC(4),COSAR(4),
     1COSBR(4),COSGR(4),PSIP(4),HCOSG(4),T(3,3),XYZDOT(3)
     2 , SINPHI(4),COSPHI(4)
      COMMON/FANDM/ FRXU(4),FRYU(4),FRZU(4),FCXU(4),FCYU(4),FCZU(4),
     1FSXU(4),FSYU(4),FSZU(4),FRIP(4),H(4),SNPHIF,SNPHIR,FZUI(4)
      COMMON/EMON/IERDAC(10),TERDAC(1C),IDACK,IENDR(20)
      COMMON/ERMON2/ IERADC(10),TERADC(10),IADCK
      COMMON/DACADC/ NAMDAC,NAMADC,IDAC,IADC,ADCNUM,DACNUM
      COMMON/AERO/SFXS,SFYS,SFZS,SNTHES,SNPHIS,SNPSIS,APLUSB,IAERO
      COMMON/DULVAR/Z3ID,Z4ID,Z5OD,Z6OD,
     1              F3RID,F4RID,F5ROD,F6ROD,
     1              U3ID,U4ID,U5OD,U6CD,
     1              V3ID,V4ID,V5OD,V6CD,
     1              W3ID,W4ID,W5OD,W6OD,
     1              UG3ID,UG4ID,UG5OD,UG6OD,
     1              VG3ID,VG4ID,VG5OD,VG6OD,
     1              UG3IDP,UG4IDP,UG5ODP,UG6ODP,
     1              S3ID,S4ID,S5OD,S6OD,
     1              CF3ID,CF4ID,CF5OD,CF6OD,
```

```
1              AMUI3,AMUI4,AMUI5,AMUI6,
1              ALTQ3P,ALTQ4P,
1              OTM3P,OTM4P,OTM5,OTM6
 COMMON/DUALS/IDULTR,NWHEEL,TIRO2,TORO2,TIRTOR,VBRZRP,
1 FXU5,FXU6,FYU5,FYU6,ALTQ5,ALTQ6,FSI3,FSI4,FSI5,FSI6,PPHIR
 COMMON/FAUL/ D1,D2,D3,D4,SFYU,TMP,SNPHIU,SNTHEU,SNPSIU,
1QDT,PDT, RDT ,UDT,VDT,WDT,PHIDT,THEDT,PSIDT,XDT,YDT,ZDT,
1 AKK1,AKK2,                                THS1,THS2,
1AMT1,AMT2,SN,SFXU,BTVD1,ETAX,ETAL,
1 ZIP(4),PHII(4),
1        U1I(4),BAMI(4),MUP(4),SAMI(4),FI(4),FXUI(4),FYUI(4),GI(4),
1        ALFI(4),BETIP(4),BETIBR(4),SLIPI(4),AM1I(4),AM2I(4),U0I(4),
1        FCI(4),FCIMAX(4),FSI(4),
1        ABI(4),BETAI(4),AMUI(4),SNI(4),RMI(4),GBI(4),FRIBR(4),
1        RWZI(4),ZI(4),FRI(4),        UI(4),VI(4),WI(4),UGI(4),
1        VGI(4),SINPSI(4),PSII(4),COSPSI(4),UGIP(4),PHICGI(4),CVI(4)
1,ALTQ(4),OTM(4),SALTQ,FOTM,ROTM
1,AP1,AP2,AP3,AP4,AR1,AR2,AR3,AR4,ANTI1,ANTI2,ANTI3,ANTI4
1,DLIS(4),ZIMX(4),FBS1,FBS2,FBS3,FBS4
1,PHIDMX
 COMMON/APL/ OPEN  ,RTSW  ,LDTSW ,RBSW
 COMMON/SPLTAX/ SPSR3,SPSR4,IAX
 COMMON/SOLDAX/ PHIFNT(07),THEFNT(07),
1      PSIFNT(7),PHIRR(7),THERR(7),PSIRR(7)
 COMMON/EXTRA/ PSI3S,PSI4S,BTV,AYSTI
 COMMON/THINGS/TMAX1,TMAX2,TMAX3,TQRMAX,TQFMAX,PSIMAX,ONER
 COMMON/CACATO/EPSK1,EPSK2,FEE1,FEE2,THE1,THE2
 COMMON/DELS/DELSWC
 COMMON/XYZ/NUMBR
 COMMON/EFFS/ANUM,ADEN,ANUMDT,ADENDT,ANUMO,ADENO,ANUMDO,ADENDO,
1   ANOUT,ADOUT
 COMMON/XBS/XB(30),NS(4,30),DELX(4),XI(4),NNN
 COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI
 COMMON/UVW/VC,UIN
 COMMON/EES/O1,O2,O3,E4,E5,E6
 COMMON/ZILCH/TQMAXF,TQMAXR,AKTQF,AKTQR,TQDRF,TQDRR,IDRSW
 COMMON/INOUT/ IN(48),DACO(48),ISW1,ISW7,IPRT
 COMMON/COMBLK/ SM,CIP,CIVP,RZF,RZR,A2T,CA20,CA23,TSFO2,
1     TRO2,TFO2,TSO2,G,THRD,TWN7,R2T,RA20,RA23
 COMMON/SWITCH/ ISW
 COMMON/OPSW/IHSW
 COMMON/SP7BLK/N1,N2,IPCT(120),IPOTAD(120),PARAM(400)
 COMMON/ADCOUT/ DEL1DT,DEL2DT,DEL3DT,DEL1,DEL2,DEL3,PHIRD,PHIR,
2 DELFW1,DELFW2,S1P,S2P,S3P,S4P
 COMMON/NEWER/TIME25,TIME10,PSI5,PHIMAX,DSWMAX
 COMMON/NONAME/XEND,O,EXIT2
 COMMON/COMVAR/ AXAVE,CUVRAT,BETDMX,CURTBP,TIMDEC,JUMP,DELSTR,DEL,
1              AXI,CURVAV,ABBTV,AYMAX,RMAX,DELBET,DELPSI,BETAMX,
1              TIMBMP,GETDL,TIMIN5,       TSTEP ,   IVHTP
 COMMON/TIMBLK/JJTIME,TIME,DT
 COMMON/DEVICE/KEYBD,ITTY,ICDRD,LPTR,LPNT
 COMMON/TRACK/JIN,IKEEP,ATRACK,ISAMP,ONTIM,OFFTIM,ITRA,
1 ITRAA,ITRNA,ITRIA
 COMMON/IO/DACPLA,ADCPLA,SCALDC,SCALAC
 COMMON/SPRING/  DLSUS1,DLSUS2,DLSUS3,DLSUS4,DELSF1(10),DELSF2(10),
1DELSR3(10),DELSR4(10),FDLSF1(10),FDLSF2(10),FDLSR3(10),FDLSR4(10),
1NDELF1,NDELF2,NDELR3,NDELR4
 COMMON/BRAKE/TQFBL,TQRBL
 COMMON/SHOCKS/ZDBPRF(10),ZDBPLF(10),ZDBPRR(10),ZDBPLR(10),
1              SAFRF(10),SAFLF(10),SAFRR(10),SAFLR(10),
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2              NRF,NLF,NRR,NLR,
3              ZETDRF,ZETDLF,ZETDRR,ZETDLR,
4              AKSRF,AKSLF,AKSRR,AKSLR,FSARF,FSALF,FSARR,FSALR
 REAL*4 ZDUMMY
 EQUIVALENCE (BVALUE(1),ZDUMMY(1))
 EQUIVALENCE  (APF(1),APF1), (APR(1),APR1), (MUS(1),MUSF),
1             (APF(2),APF2), (APR(2),APR2), (MUS(2),MUSR)
 EQUIVALENCE
1   (PARAM( 1),AMS)     , (PARAM( 2),AMUF)   , (PARAM( 3),AMUR)    ,
1   (PARAM( 4),ZF)      , (PARAM( 5),ZR)     , (PARAM( 6),A)       ,
1   (PARAM( 7),B)       , (PARAM( 8),TF)     , (PARAM( 9),TR)      ,
1   (PARAM(10),TS)      , (PARAM(11),AIX)    , (PARAM(12),AIY)     ,
1   (PARAM(13),AIZ)     , (PARAM(14),AIXZ)   , (PARAM(15),AIR)     ,
1   (PARAM(16),CF)      , (PARAM(17),RF)     ,
1   (PARAM(19),AKF1)    , (PARAM(20),AKF2)   , (PARAM(21),AKR3)    ,
1   (PARAM(22),AKR4)    , (PARAM(23),CR)     , (PARAM(24),RR)      ,
1   (PARAM(25),CF1P)    , (PARAM(26),CF2P)   , (PARAM(27),CR3P)    ,
1   (PARAM(28),CR4P)                         , (PARAM(30),AKRS)    ,
1   (PARAM(31),RW)      , (PARAM(32),SCALE)  , (PARAM(33),OT)      ,
1   (PARAM(34),CA0)     , (PARAM(35),CA1)    , (PARAM(36),CA2)     ,
1   (PARAM(37),CA3)     , (PARAM(38),CA4)    , (PARAM(39),TIR )    ,
1   (PARAM(44),LAFT)    , (PARAM(41),AKSC)   , (PARAM(42),ANG)     ,
1   (PARAM(43),LAFC)    , (PARAM(40),TOR )   , (PARAM(45),LARC)
 EQUIVALENCE
1   (PARAM(46),LART)    , (PARAM(47),AIPW)   , (PARAM(48),AIF)     ,
1   (PARAM(49),AIWF)    , (PARAM(50),AIWR)   , (PARAM(51),AID)     ,
1   (PARAM(52),ARBR)    , (PARAM(53),TSF )   , (PARAM(54),AKFS)    ,
1   (PARAM(55),PTBR)    , (PARAM(56),YSA1)   , (PARAM(57),YSA2)    ,
1   (PARAM(58),YHS1)    , (PARAM(59),YHS2)   , (PARAM(60),AKD)     ,
1   (PARAM(61), AIDF)   , (PARAM(62),ARFBR)  , (PARAM(63),PIN)     ,
1   (PARAM(64),QIN)     , (PARAM(65),RIN)    , (PARAM(66),UIZ)     ,
1   (PARAM(67),VIN)     , (PARAM(68),WIN)    , (PARAM(69),XIN)     ,
1   (PARAM(70),YIN)     , (PARAM(71),ZIN)    , (PARAM(72),THEIN)   ,
1   (PARAM(73),PHIIN)   , (PARAM(74),PSIIN)  , (PARAM(75),DTIN)    ,
1   (PARAM(76),TEND)    , (PARAM(77),AKT1)   , (PARAM(78),AKT2)   ,
1   (PARAM(79),AKT3)    , (PARAM(80),AKT4)   , (PARAM(81),RPS1)   ,
1   (PARAM(82),RPS2)    , (PARAM(83),RPS3)   , (PARAM(84),RPS4)    ,
1   (PARAM(85),B1)      , (PARAM(86),B2)     , (PARAM(87),B3)
 EQUIVALENCE
1 (PARAM(88),B4),         (PARAM( 89),DEL1DN),(PARAM( 90),DEL2DN),
1   (PARAM( 91),DEL3DN),(PARAM( 92),DELFIN), (PARAM( 93),DELRIN),
1   (PARAM( 94),DEL3IN), (PARAM( 95),PHIDN), (PARAM(96),PHIRN),
1   (PARAM( 97),DFW1IN), (PARAM( 98),DFW2IN),(PARAM( 99),U1PIN),
1   (PARAM(100),U2PIN),  (PARAM(101),U3PIN), (PARAM(102),U4PIN),
1   (PARAM(103),S1PIN),  (PARAM(104),S2PIN), (PARAM(105),S3PIN),
1   (PARAM(106),S4PIN), (PARAM(107),PPRT),(PARAM(108),FREQ)
1,(PARAM(110),TQMAX),(PARAM(111),AKTQ),(PARAM(112),VCIN)
1,(PARAM(113),SWMT),(PARAM(114),DSWCM),(PARAM(115),TST),
1(PARAM(116),DSLP),(PARAM(117),CGAM),(PARAM(118),CS)
1  ,(PARAM(119),TQRBR),(PARAM(120),TQFBR)
1  ,(PARAM(121),PFL),(PARAM(122),TTD),(PARAM(123),DSW)
1    ,(PARAM(124),TSW)
 EQUIVALENCE
1  (PARAM(130),AMCR),(PARAM(131),ESP),(PARAM(132),AKSL1),
1  (PARAM(133),AKSL2),(PARAM(134),AA1),(PARAM(135),AA2),
1  (PARAM(136),CCR),(PARAM(137),CFCR),(PARAM(138),AP),
1  (PARAM(139),EP1),(PARAM(140),EP2),
1 (PARAM(169),SNT),(PARAM(170),SNS0),(PARAM(171),SNS1),
1    (PARAM(182),SII(1))
 EQUIVALENCE (PARAM(202),APF(1)),(PARAM(204),APR(1)),
1   (PARAM(206),MUS(1))
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```
      EQUIVALENCE (AKLR,PARAM(212)),(KOTF,PARAM(213)),(KOTR,PARAM(214))
      EQUIVALENCE
     1   (PARAM(223),CR1C),(PARAM(224),CR1T),(PARAM(225),CR2C),
     1   (PARAM(226),CR2T),(PARAM(227),CR3C),(PARAM(228),CR3T),
     1   (PARAM(229),CR4C),(PARAM(230),CR4T),(PARAM(231),AH1),
     1   (PARAM(232),AH2),(PARAM(233),ALAMBD)   ,
     1 (PARAM(242),AKCF),(PARAM(243),AKCR),(PARAM(244),AKSR)
      EQUIVALENCE (PARAM(236),PSO1),(PARAM(237),PSO2)
      EQUIVALENCE (PARAM(245),RB(1)),(PARAM(249),TFK(1)),
     1            (PARAM(252),TRK(1)),
     1            (PARAM(255),OFC0),(PARAM(256),OFC1),(PARAM(257),OFC2),
     1            (PARAM(258),OFC3),(PARAM(262),ORC3),
     1            (PARAM(259),ORC0),(PARAM(260),ORC1),(PARAM(261),ORC2)
      EQUIVALENCE (PARAM(263),CP0F),(PARAM(264),CP1F),
     1(PARAM(265),CP2F),(PARAM(266),CP0R),(PARAM(267),CP1R),
     1(PARAM(268),CP2R),(PARAM(269),CR0F),(PARAM(270),CR1F),
     1(PARAM(271),CR2F),(PARAM(272),CR0R),(PARAM(273),CR1R),
     1(PARAM(274),CR2R)
      EQUIVALENCE (RB(1),RB1),(RB(2),RB2)
      EQUIVALENCE (RB(3),RB3),(RB(4),RB4)
      EQUIVALENCE (TFK(1),AFK1),(TRK(1),ARK1)
      EQUIVALENCE (TFK(2),AFK2),(TRK(2),ARK2)
      EQUIVALENCE (TFK(3),AFK3),(TRK(3),ARK3)
      EQUIVALENCE
     1   (PARAM(284),HFC),(PARAM(285),HRC),
     1   (PARAM(290),ROT),(PARAM(291),RA0),(PARAM(292),RA1),
     1   (PARAM(293),RA2),(PARAM(294),RA3),(PARAM(295),RA4)
      EQUIVALENCE (PARAM(351),IOUT(1))
      EQUIVALENCE (RWZI(1),RWZ1),(ZI(1),Z1),(FRI(1),FR1),(AKTI(1),AKT1),
     1            (RWZI(2),RWZ2),(ZI(2),Z2),(FRI(2),FR2),(AKTI(2),AKT2),
     1            (RWZI(3),RWZ3),(ZI(3),Z3),(FRI(3),FR3),(AKTI(3),AKT3),
     1            (RWZI(4),RWZ4),(ZI(4),Z4),(FRI(4),FR4),(AKTI(4),AKT4),
     1(UI(1),U1),(VI(1),V1),(WI(1),W1),(UGI(1),UG1),(VGI(1),VG1),
     1(UI(2),U2),(VI(2),V2),(WI(2),W2),(UGI(2),UG2),(VGI(2),VG2),
     1(UI(3),U3),(VI(3),V3),(WI(3),W3),(UGI(3),UG3),(VGI(3),VG3),
     1(UI(4),U4),(VI(4),V4),(WI(4),W4),(UGI(4),UG4),(VGI(4),VG4),
     1(SINPSI(1),SINPS1),(PSII(1),PSI1),(COSPSI(1),COSPS1),(UGIP(1),UG1P
     1),(PHICGI(1),PHICG1),(CVI(1),CV1),(ABI(1),AB1),(BETAI(1),BETA1),
     1(SINPSI(2),SINPS2),(PSII(2),PSI2),(COSPSI(2),COSPS2),(UGIP(2),UG2P
     1),(PHICGI(2),PHICG2),(CVI(2),CV2),(ABI(2),AB2),(BETAI(2),BETA2),
     1(SINPSI(3),SINPS3),(PSII(3),PSI3),(COSPSI(3),COSPS3),(UGIP(3),UG3P
     1),(PHICGI(3),PHICG3),(CVI(3),CV3),(ABI(3),AB3),(BETAI(3),BETA3),
     1(SINPSI(4),SINPS4),(PSII(4),PSI4),(COSPSI(4),COSPS4),(UGIP(4),UG4P
     1),(PHICGI(4),PHICG4),(CVI(4),CV4),(ABI(4),AB4),(BETAI(4),BETA4)
      EQUIVALENCE (AMUI(1),AMU1),(SNI(1),SN1),(RMI(1),RM1),(GBI(1),GB1),
     1            (AMUI(2),AMU2),(SNI(2),SN2),(RMI(2),RM2),(GBI(2),GB2),
     1            (AMUI(3),AMU3),(SNI(3),SN3),(RMI(3),RM3),(GBI(3),GB3),
     1            (AMUI(4),AMU4),(SNI(4),SN4),(RMI(4),RM4),(GBI(4),GB4),
     1(FRIBR(1),FR1BR),(ALFI(1),ALF1),(BETIP(1),BET1P),(BETIBR(1),BET1BR
     1),(SLIPI(1),SLIP1),(AM1I(1),AM11),(AM2I(1),AM21),(U0I(1),U01),
     1(FRIBR(2),FR2BR),(ALFI(2),ALF2),(BETIP(2),BET2P),(BETIBR(2),BET2BR
     1),(SLIPI(2),SLIP2),(AM1I(2),AM12),(AM2I(2),AM22),(U0I(2),U02),
     1(FRIBR(3),FR3BR),(ALFI(3),ALF3),(BETIP(3),BET3P),(BETIBR(3),BET3BR
     1),(SLIPI(3),SLIP3),(AM1I(3),AM13),(AM2I(3),AM23),(U0I(3),U03),
     1(FRIBR(4),FR4BR),(ALFI(4),ALF4),(BETIP(4),BET4P),(BETIBR(4),BET4BR
     1),(SLIPI(4),SLIP4),(AM1I(4),AM14),(AM2I(4),AM24),(U0I(4),U04),
     1(U1I(1),U11),(BAMI(1),BAM1),(SII(1),SI1),(SAMI(1),SAM1),(FI(1),F1)
     1,
     1(U1I(2),U12),(BAMI(2),BAM2),(SII(2),SI2),(SAMI(2),SAM2),(FI(2),F2)
     1,
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     1(U1I(3),U13),(BAMI(3),BAM3),(SII(3),SI3),(SAMI(3),SAM3),(FI(3),F3)
     1,
     1(U1I(4),U14),(BAMI(4),BAM4),(SII(4),SI4),(SAMI(4),SAM4),(FI(4),F4)
      EQUIVALENCE (FXUI(1),FXU1),(FYUI(1),FYU1),(GI(1),G1),(FCI(1),FC1),
     1            (FXUI(2),FXU2),(FYUI(2),FYU2),(GI(2),G2),(FCI(2),FC2),
     1            (FXUI(3),FXU3),(FYUI(3),FYU3),(GI(3),G3),(FCI(3),FC3),
     1            (FXUI(4),FXU4),(FYUI(4),FYU4),(GI(4),G4),(FCI(4),FC4),
     1(FCIMAX(1),FC1MAX),(FSI(1),FS1),
     1(FCIMAX(2),FC2MAX),(FSI(2),FS2),
     1(FCIMAX(3),FC3MAX),(FSI(3),FS3),
     1(FCIMAX(4),FC4MAX),(FSI(4),FS4)
      EQUIVALENCE (ZIP(1),Z1P),(PHII(1),PHI1),
     1            (ZIP(2),Z2P),(PHII(2),PHI2),
     1            (ZIP(3),Z3P),(PHII(3),PHI3),
     1            (ZIP(4),Z4P),(PHII(4),PHI4)
      EQUIVALENCE (DL1S,DLIS(1)),(DL2S,DLIS(2)),(DL3S,DLIS(3))
     1           ,(DL4S,DLIS(4))
      EQUIVALENCE (PHIFD,DEL2DT)  ,(PHIF,DEL2)
      EQUIVALENCE  (PHIRD,DEL4DT),(PHIR,DEL4)
      EQUIVALENCE (DLSUSI(1),DLSUS1),(DLSUSI(2),DLSUS2),
     1            (DLSUSI(3),DLSUS3),(DLSUSI(4),DLSUS4)
      EQUIVALENCE (FZUI(1),FZU1),(FZUI(2),FZU2),
     1    (FZUI(3),FZU3),(FZUI(4),FZU4)
      EQUIVALENCE (VARZRP,VERZRP)
      EQUIVALENCE (FEE1,FEE(1)),(FEE2,FEE(2))
      REAL*4 KOTF,KOTR
      REAL*4 FEE(2)
      DATA RAD/0.1745329E-1/
      DATA MPHIPS/17.6/
      REAL*4 MPHIPS
      REAL*4 MUP    ,MUS(2),RE(4),TFK(3),TRK(3),SII(4),APF(2),APR(2)
      REAL*4 LAFC,LAFT,LARC,LART
      REAL*4 AKTI(4)
      REAL*4 ATRACK(2000)
      INTEGER*2 ITRAA(50),ITRNA(50),ITRIA(50),DACPLA(48),ADCPLA(48)
      INTEGER*2 NAMDAC(48),NAMADC(48),IDAC(48),IADC(48),ADCNUM,DACNUM
      REAL*4 IOUT(48),IN,      SCALAC(48),SCALDC(48)
      REAL*4 DLSUSI(4),PCGI(4),SNPSIP(4)
      REAL*4 BVALUE(2)
      INTEGER*2   RTSW  ,RBSW  ,LDTSW ,OPEN
C     ******************************************************************
C     USE A/D READ VALUES
C     CHECK FOR A/D OVER RANGE
C     ******************************************************************
      DO 10100 I=1,ADCNUM
      SADCO =    IN(I)
          IN(I) = AMAX1(-.9998,(AMIN1(.9998,  IN(I))))
      IF(SADCO.EQ.  IN(I)) GO TO 10105
      IADCK = IADCK+1
      IF(IADCK.GE.10) IADCK = 10
      IERADC(IADCK) = I
      TERADC(IADCK) = TIME
10105 CONTINUE
      BVALUE(ADCPLA(I))=IN(I)*SCALAC(I)
10100 CONTINUE
      IHSW=1
      TIME=FLOAT(JJTIME)*DT
      JJTIME=JJTIME+1
      ENTRY SBPG22
```

```
      ISW=1
      IF(TIME.GT.0.) GO TO 6
      DO 5 K=1,4
      FSI(K) = 0.
      ALTQ(K) = 0.
      ZIMX(K) = 100.
    5 CONTINUE
      PHIDMX = 0.
      CONVRT = 1./MPHIPS
C     AERODYNAMIC INITIALIZATION VARIABLES
      SFXS =0.
      SFYS =0.
      SFZS =0.
      SNTHES=0.
      SNPHIS =0.
      SNPSIS=0.
C     DUAL TIRE INITIALIZATION VARIABLES
      ALTQ5=0.0
      ALTQ6=0.0
      FSI3=0.0
      FSI4=0.0
      FSI5=0.0
      FSI6=0.0
      FXU5=0.0
      FXU6=0.0
      FYU5=0.0
      FYU6=0.0
      SNPHIF=0.0
      SNPHIR=0.0
      SFSF = PARAM(32)/10000.
      NBMP=PARAM(277)+0.5
C     STOPPING DISTANCE INITIALIZATION
      ANUM=0.0
      ANUMDT=0.0
    6 CONTINUE
C FUNCTION:  PSIFNT-COEFFICIENTS TO A POLYNOMIAL FIT OF FRONT WHEEL     C
C            TOE-IN AS A FUNCTION OF SUSPENSION DEFLECTION (DELI)       C
C                                                                       C
C INPUTS:    PSIFNT-(DEGREES/INCH)                                      C
C            DELI-(INCHES)
C     ***************************************************************
C     INCREASING THE SPRUNG MASS CVER THAT FOR WHICH THE STATIC WHEEL
C     DEFLECTION IS MEASURED, YIELDS A DELFIN AND A DELRIN WHICH
C     IS A NEGATIVE NUMBER
C     ***************************************************************
C     DELFIN AND DELRIN REPRESENT A CHANGE IN STATIC DISPLACEMENT
C     OF THE FRONT AND REAR WHEELS DUE TO LOAD CONFIGURATIONS
C OUTPUTS:   POLY-(DEGREES)                                             C
C                                                                       C
C     DLIS (I=1,2,3,4) IS THE SUSPENSION DEFLECTION RELATIVE
C           TO THE UNLOADED POSITION FOR WHEEL I
C     SUSPENSION TIME DELAY COMPENSATION
      DEL1=DEL1+PARAM(341)*DEL1DT
      DEL2=DEL2+PARAM(342)*DEL2DT
      DEL3=DEL3+PARAM(343)*DEL3DT
      PHIR=PHIR+PARAM(344)*PHIRD
      DL1S = DEL1 + DELFIN
      DL2S = DEL2 + DELFIN
      DL3S = DEL3 + DELRIN
      DL4S = DEL4 + DELRIN
```

```
      DLSUS1=DL1S
      DLSUS2=DL2S
      DLSUS3=DL3S
      DLSUS4=DL4S
C     IAX = 0   SOLID FRONT AND REAR SUSPENSIONS
C         = 1   INDEPENDENT FRONT AND SOLID REAR SUSPENSIONS
C         = 2  INDEPENDENT FRONT AND REAR SUSPENSIONS
      IF(IAX.EQ.0) DL1S = DL1S +  TFO2*PHIF
      IF(IAX.EQ.0) DL2S = DEL1 + DELFIN - TFO2*PHIF
      IF(IAX.LE.1) DL3S = DL3S    + TRO2*PHIR
      IF(IAX.LE.1) DL4S = DEL3 + DELRIN - TRO2*PHIR
C     SUSPENSION DEFLECTIONS FOR SPRING FORCES
      IF(IAX.EQ.0) DLSUS1 = DLSUS1 + TSF*PHIF/2.
      IF(IAX.EQ.0) DLSUS2 =  DEL1 + DELFIN - TSF*PHIF/2.
      IF(IAX.LE.1)DLSUS3=DLSUS3+TSO2*PHIR
      IF(IAX.LE.1) DLSUS4 = DEL3 + DELRIN -TSO2*PHIR
C     INDEPENDENT FRONT & SOLID REAR
      PSI1=DELFW1+(POLY(DL1S,PSIFNT))*RAD+EPSK1
      PSI2=DELFW2-(POLY(DL2S,PSIFNT))*RAD+EPSK2
      PSI3S = AKRS*PHIR
     1 + AKLR*FSI(3)
      PSI4S = AKRS*PHIR
     1 + AKLR*FSI(4)
C                                                                  C
C FUNCTION:  PHIFNT-COEFFICIENTS TO A POLYNOMIAL FIT OF FRONT WHEEL C
C            CAMBER AS A FUNCTION OF SUSPENSION DEFLECTION (DELI)  C
C                                                                  C
C INPUTS:    PHIFNT-(DEGREES/INCH)                                 C
C            DELI-(INCHES)
C
C OUTPUTS:   POLY-(DEGREES)                                        C
C                                                                  C
      PHIPY1 = (POLY(DL1S,PHIFNT))*RAD
      PHIPY2 = (POLY(DL2S,PHIFNT))*RAD
      PHISA1   = PHIPY1 - PHIFNT(1)*RAD + YHS1
      PHISA2   =-PHIPY2 + PHIFNT(1)*RAD + YHS2
      PHI1 = PHIPY1 + SIGN(1.,FS1)*FEE1  - PHISA1*(1.-COS(PSII(1)))
     1 + KOTF*OTM(1)
      PHI2 =-PHIPY2 + SIGN(1.,FS2)*FEE2 -PHISA2*(1.-COS(PSII(2)))
     1 + KOTF*OTM(2)
      PHI3=PHIR
      PHI4=PHIR
C                                                                  C
C FUNCTION:  THEFNT-CASTER AS A FUNCTION OF SUSPENSION             C
C            DEFLECTION (DELI)                                     C
C                                                                  C
C INPUTS:    THEFNT (DEGREES/INCH)                                 C
C            DELI-(INCHES)                                         C
C                                                                  C
C OUTPUT:    POLY-(DEGREES)                                        C
C                                                                  C
      THS1=(POLY(DL1S,THEFNT))*RAD+THE1
      THS2=(POLY(DL2S,THEFNT))*RAD+THE2
C                                                                  C
C FUNCTION:  PSIRR-COEFFICIENTS TO A POLYNOMIAL FIT OF REAR WHEEL  C
C            TOE-IN AS A FUNCTION OF SUSPENSION DEFLECTION (DELI)  C
C                                                                  C
C INPUTS:    PSIRR-(DEGREES/INCH)                                  C
C            DELI-(INCHES)                                         C
C                                                                  C
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C OUTPUTS:   POLY-(DEGREES)                                           C
C                                                                     C
C                                                                     C
C FUNCTION:  PHIRR-COEFFICIENTS TO A POLYNOMIAL FIT OF REAR WHEEL      C
C            CAMBER AS A FUNCTION OF SUSPENSION DEFLECTION (DELI)     C
C                                                                     C
C INPUTS:    PHIRR-(DEGREES/INCH)                                     C
C            DELI-(INCHES)                                            C
C                                                                     C
C OUTPUTS:   POLY-(DEGREES)                                           C
C                                                                     C
C     INDEPENDENT REAR                                                C
      IF(IAX.LE.1)GO TO 7843
      PSI3S = POLY(DL3S,PSIRR)*RAD
     1 + AKLR*FSI(3)
      PSI4S = -POLY(DL4S,PSIRR)*RAD
     1 + AKLR*FSI(4)
      PHI3 =POLY(DL3S,PHIRR)*RAD
     1 + KOTR*OTM(3)
      PHI4=-POLY(DL4S,PHIRR)*RAD
     1 + KOTR*OTM(4)
 7843 CONTINUE
      IF(IAX.NE.0.) GO TO 7844
C     SOLID FRONT
      PSI1 = DELFW1-AKFS*PHIF+EPSK1
      PSI2 = DELFW2-AKFS*PHIF+EPSK2
      PHI1 = PHIF+FEE1
      PHI2 = PHIF+FEE2
 7844 CONTINUE
      IF(IDULTR.EQ.1) ALTQ(3) = ALTQ(3)/2.
      IF(IDULTR.EQ.1) ALTQ(4) = ALTQ(4)/2.
      PSI3 = PSI3S+ ALTQ(3)*AKSR
      PSI4 = PSI4S+ ALTQ(4)*AKSR
      PHS1=YHS1+PHI1
      PHS2=YHS2+PHI2
C     CALCULATION OF FRONT BUMP STOP FORCES
      FBS1 = XINT(DLSUS1,DELSF1,FDLSF1,NDELF1)
      FBS1 = FBS1 - AKF1*DLSUS1
      FBS2 = XINT(DLSUS2,DELSF2,FDLSF2,NDELF2)
      FBS2 = FBS2 - AKF2*DLSUS2
C     CALCULATION OF REAR BUMP STOP FORCES
      FBS3 = XINT(DLSUS3,DELSR3,FDLSR3,NDELR3)
      FBS3 = FBS3 - AKR3*DLSUS3
      FBS4 = XINT(DLSUS4,DELSR4,FDLSR4,NDELR4)
      FBS4 = FBS4 - AKR4*DLSUS4
C     CALCULATION OF SHOCK ABSORBER FORCES
      FSARF=XINT(ZETDRF,ZDBPRF,SAFRF,NRF)
      FSARF=FSARF-AKSRF*ZETDRF
      FSALF=XINT(ZETDLF,ZDBPLF,SAFLF,NLF)
      FSALF=FSALF-AKSLF*ZETDLF
      FSARR=XINT(ZETDRR,ZDBPRR,SAFRR,NRR)
      FSARR=FSARR-AKSRR*ZETDRR
      FSALR=XINT(ZETDLR,ZDBPLR,SAFLR,NLR)
      FSALR=FSALR-AKSLR*ZETDLR
      NNN=PARAM(198)/(PARAM(75)*U    )+0.5
C***** COOD TRANSFORMATION *******
      CTH=COS(THE)
      CPH=COS(PHI)
      CPS=COS(PSI)
```

```
      STH=SIN(THE)
      SPS=SIN(PSI)
      SPH=SIN(PHI)
      CPHSPS=CPH*SPS
      SPHCPS=SPH*CPS
      CPHCPS=CPH*CPS
      SPSSPH=SPS*SPH
      T(1,1)=CPS*CTH
      T(2,1)=SPS*CTH
      T(3,1)=-STH
      T(1,2)=SPHCPS*STH-CPHSPS
      T(2,2)=CPHCPS+SPSSPH*STH
      T(3,2)=SPH*CTH
      T(1,3)=SPSSPH+CPHCPS*STH
      T(2,3)=CPHSPS*STH-SPHCPS
      T(3,3)=CTH*CPH
C     ******************************************************************
C***** COSINE OF ALPHA BETA AND GAMMA FOR SUBS R,C,ANDH*****
      DO 16 K=1,4
      SINPSI(K)=SIN(PSII(K))
      COSPSI(K)=COS(PSII(K))
      SINPHI(K)=SIN(PHII(K))
      COSPHI(K)=COS(PHII(K))
   16 CONTINUE
C*****COS ALPHA YWI=COSABG(1,I),COS BETA YWI=COSABG(2,I)
C***  COS GAMMA YWI=COSABG(3,I)
      DO 22 J=1,3
      DO 23 K=1,4
      COSABG(J,K)=-T(J,1)*SINPSI(K)+T(J,2)*COSPHI(K)*COSPSI(K)
     1  +T(J,3)*SINPHI(K)*COSPSI(K)
   23 CONTINUE
   22 CONTINUE
      DO 26 I=1,4
      C2BETA = COSABG(2,I)*COSABG(2,I)
      DEN1 = SQRT(COSABG(1,I)*COSABG(1,I) + C2BETA)
      COSAC(I) = COSABG(2,I)/DEN1
      COSBC(I) = -COSABG(1,I)/DEN1
      COSAR(I) = -COSABG(1,I)*COSABG(3,I)/DEN1
      COSBR(I) = -COSABG(3,I)*COSABG(2,I)/DEN1
      COSGR(I) = DEN1
      SNPSIP(I) = -(T(1,1)*COSABG(1,I) + T(2,1)*COSABG(2,I))/(DEN1*CTH)
      PSIP(I) = ARSIN(SNPSIP(I))
      IF(PARAM(276).LT.0.) PSIP(I) = PSII(I)
      PCGI(I) = ARSIN(COSABG(3,I))
      IF(I.GT.2) GO TO 27
      PHICGI(I) = PCGI(I) + AKCF*FSI(I)
      IF(IAX.EQ.0) PHICGI(I) = PHICGI(I) + FEE(I)
      GO TO 26
   27 CONTINUE
      PHICGI(I) = PCGI(I) + AKCR*FSI(I)
      IF(PARAM(276).EQ.1.) PHICGI(I) = 0.
      IF(PARAM(276).EQ.9.) PHICGI(I) = 0.
   26 CONTINUE
      DO 24 J=1,3
      DO 25 K=1,4
      COABGH(J,K)=T(1,J)*COSAR(K)+T(2,J)*COSBR(K)+T(3,J)*COSGR(K)
   25 CONTINUE
   24 CONTINUE
C ********************************************************************
C
```

```
C     INTEGRATION OF DERIVATIVES DONE NEXT                                      6390
C                                                                               6360
      DO 15  I=1,3
      XYZDOT(I)=U*T(I,1)+V*T(I,2)+W*T(I,3)
   15 CONTINUE
      Z=Z+XYZDOT(3)*DT
      X=X
      Y=Y
      IF(PARAM(218).GT.0.5) GO TO 8999
      X=X+XYZDOT(1)*DT
      Y=Y+XYZDOT(2)*DT
 8999 CONTINUE
C***********************************************************************
C***** STOPPING DISTANCE COMPUTATIONS **********************************
      IF(TIME.LT.CGAM) GO TC 9000
      ANUMDT = SQRT(U**2 + V**2)                                                6220
      ANUM=ANUM+ANUMDT*DT
 9000 CONTINUE
C***********************************************************************
C******* Z COMPUTATION ********
  100 TM1=Z+T(3,1)*A+T(3,3)*ZF
      TM2=T(3,2)*TFO2
      Z1=TM1+TM2+T(3,3)*DEL1  -DELX(1)
      IF(IAX.EQ.0) Z1=Z1+T(3,3)*TFO2*PHIF
      Z2=TM1-TM2+T(3,3)*DEL2-DELX(2)
      IF(IAX.EQ.0) Z2=Z2+T(3,3)*(-TFO2*PHIF-DEL2+DEL1)
      TM1=Z-T(3,1)*B+T(3,3)*ZR
      TM2=T(3,2)*TRO2
      Z3=TM1+TM2+T(3,3)*DEL3-DELX(3)
      IF(IAX.LE.1) Z3=Z3+T(3,3)*TRO2*PHIR
      Z4=TM1-TM2+T(3,3)*DEL4-DELX(4)
      IF(IAX.LE.1) Z4=Z4+T(3,3)*(-TRO2*PHIR-DEL4+DEL3)
C     ******************************************************************
C     CALCULATION OF TIRE ROLLING RADIUS
      DO 110 K=1,4
      H(K)=-ZI(K)/COSGR(K)
      IF(PARAM(276).EQ.2.) H(K) = -ZI(K)
      IF(PARAM(276).EQ.5.) H(K) = -ZI(K)
      IF(PARAM(276).EQ.9.) H(K) = -ZI(K)
      IF(H(K).GT.RW) H(K)=RW
  110 CONTINUE
C***********************************************************************
C     WHEEL SPIN RATE X ROLLING RADIUS
      SPINH1=ARPS(1)*H(1)
      SPINH2=ARPS(2)*H(2)
C **********************************************************************
C
C***** COMPUTATION OF U,V, AND W FOR VARIOUS AXLES******
C******* THIS SECTION COMPUTES THE U'S,V'S,AND W'S FOR ALL AXLE CONFIGURATIONS
      TM1=U+ZF*Q
      TM2=TFO2*R
      TM11=U+ZR*Q
      TM22=TRO2*R
      VARZFP=V+A*R-ZF*P
      VARZRP=V-B*R-ZR*P
      PPHIR=P+PHIRD
      PPHIF=P+PHIFD
      WAQ=W-A*Q
      WBQ=W+B*Q
      IF(IAX-1) 4,55,56
```

```
C****SOLID FRONT AXLE EQUATICNS (A) ******
  4   U1=TM1-TM2+Q*(TFO2*PHIF+DEL1)
      U2=TM1+TM2+Q*(-TFO2*PHIF+DEL1)
      V1=VARZFP-DEL1  *P-(TFC2*PHIF+   H(1)*COABGH(3,1))*PPHIF
      V2=VARZFP-DEL1  *P-(-TFO2*PHIF+   H(2)*COABGH(3,2))*PPHIF
      W1=WAQ+DEL1DT-(-TFO2-H(1)*CCABGH(2,1))*PPHIF
      W2=WAQ+DEL1DT-(TFO2-H(2)*COABGH(2,2))*PPHIF
C**** SOLID REAR EQUATIONS (B) *****
 55   U3=TM11-TM22+Q*(TRO2*PHIR+DEL3)
      U4=TM11+TM22+Q*(-TRO2*PHIR+DEI3)
      V3=VARZRP-DEL3  *P-(TRO2*PHIR+   H(3)*COABGH(3,3))*PPHIR
      V4=VARZRP-DEL3  *P-(-TRO2*PHIR+   H(4)*COABGH(3,4))*PPHIR
      W3=WBQ+DEL3DT-(-TRO2-H(3)*COAEGH(2,3))*PPHIR
      W4=WBQ+DEL3DT-(TRO2-H(4)*COABGH(2,3))*PPHIR
      IF(IAX.EQ.0) GO TO 7
C****  INDPENDENT FRONT AXLE EQUATICNS (C) ********
 56   U1 = TM1-TM2 + Q*DEL1
      U2=TM1+TM2+Q*DEL2
      V1=VARZFP-(DEL1+H(1)*CCABGH(3,1))*P
      V2=VARZFP-(DEL2+H(2)*COABGH(3,2))*P
      W1=WAQ+DEL1DT+(TFO2+H(1)*COABGH(2,1))*P
      W2=WAQ+DEL2DT-(TFO2-H(2)*COABGH(2,2))*P
      IF(IAX.EQ.1) GO TO 7
C**** INDEPENDENT REAR AXLE EQUATIONS (D) *******
      U3=TM11-TM22+Q*DEL3
      U4=TM11+TM22+Q*DEL4
      V3=VARZRP-(DEL3  +   H(3)*CCAEGH(3,3))*P
      V4=VARZRP-(DEL4+H(4)*COABGH(3,4))*P
      W3=WBQ+DEL3DT+(TRO2+H(3)*COABGH(2,3))*P
      W4=WBQ+DEL4DT-(TRO2-H(4)*COABGH(2,4))*P
  7   CONTINUE
C****** COSINE OF THETA XGI SIN THETA XGI BETA I PSII*******
      COTHXG=T(3,3)/SQRT(CPH*CPH+SPH*SPH*STH*STH)
      SITHXG=COTHXG*STH/T(3,3)
      DO 30 K=1,4
      VGI(K)=VI(K)*CPH-WI(K)*SPH
      UGI(K)=UI(K)*COTHXG+WI(K)*SITHXG
      IF(PARAM(276).EQ.3.) UGI(K) = UI(K) + THE*WI(K)
      IF(PARAM(276).EQ.9.) UGI(K) = UI(K) + THE*WI(K)
      CVI(K)=SQRT(UI(K)*UI(K)+VI(K)*VI(K))*CONVRT
      ABI(K)=ABS(UGI(K))
      UGIP(K)=UGI(K)*COS(PSIP(K))+VGI(K)*SNPSIP(K)
      BETAI(K)=ATAN(VGI(K)/ABI(K))-SIGN(1.,UGI(K))*PSIP(K)
      SNI(K)=SNSO/SNT
      SLIPI(K) = 1.- ARPS(K)*H(K)/UGIP(K)
      IF(SLIPI(K).LT.(-1.).OR.SLIPI(K).GT.1.) SLIPI(K)=SIGN(1.,SLIPI(K))
 30   CONTINUE
C     INTFUN IS USED FOR ROAC PATCH WITH VARYING COEFFICIENT OF FRICTION
      INTFUN=PARAM(172)+0.5
      IF(INTFUN.EQ.0)GO TO 3497
      IF(INTFUN.NE.1)GO TO 3498
      X1 = A*CPS - TFO2*SPS + X
      X2 = A*CPS + TFO2*SPS + X
      X3= -B*CPS - TRO2*SPS + X
      X4= -B*CPS + TRO2*SPS + X
      TEMP=PARAM(173)+PARAM(174)
      TEMP=TEMP*12.0
      PPPP=PARAM(173)*12.0
      IF(X1.GT.PPPP     .ANC.X1.LE.TEMP)SN1=SNS1/SNT
      IF(X2.GT.PPPP     .AND.X2.LE.TEMP)SN2=SNS1/SNT
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```
      IF(X3.GT.PPPP      .AND.X3.LE.TEMP) SN3=SNS1/SNT
      IF(X4.GT.PPPP      .AND.X4.LE.TEMP) SN4=SNS1/SNT
      GO TO 3498
 3497 CONTINUE
      YY1 = A*SPS + TFO2*CPS + Y
       Y2 = A*SPS - TFO2*CPS + Y
       Y3 =-B*SPS + TRO2*CPS + Y
       Y4 =-B*SPS - TRO2*CPS + Y
      IF(YY1.LT.0.0) SN1=SNS1/SNT
      IF(Y2.LT.0.0)SN2=SNS1/SNT
      IF(Y3.LT.0.0) SN3=SNS1/SNT
      IF(Y4.LT.0.0)SN4=SNS1/SNT
 3498 CONTINUE
C**** COMPUTATION OF ROLLING RADIUS,RADIAL FORCE,AND NORMAL FORCE ***
C *** RWZI IS THE TIRE DEFLECTION *****
      DO 20 K=1,4
      RWZI(K)=RW-H(K)
      IF(RWZI(K).LT.ZIMX(K)) ZIMX(K)=RWZI(K)
      FRIP(K)=0.
      IF(RWZI(K).GT.0.) FRIP(K)=AKTI(K)*RWZI(K)
      FRIPP=0.
      IF(RWZI(K).GT.0.) FRIPP= -FSI(K)*TAN(PHICGI(K))
      IF((FRIP(K) + FRIPP).LE.0.) FRIPP = 0.
      FRI(K) = FRIP(K)/COS(PHICGI(K)) + FRIPP
      IF(PARAM(276).EQ.4.) FRI(K) = FRIP(K)
      IF(PARAM(276).EQ.5.) FRI(K) = FRIP(K)
      IF(PARAM(276).EQ.9.) FRI(K) = FRIP(K)
  20  CONTINUE
C     CALCULATION OF SIDE FORCE FRICTION COEFF
C
      CALL LFRIC
C
C     CIRCUMFERENTIAL FRICTICN COEFF CALCULATION
C
      CALL CFRIC
C
C
C ***** COMPUTATION OF TIRE FORCES*********
      DO 45 K=1,4
      IF(PARAM(276).NE.7.)GO TO 120
      FXUI(K) = FRI(K)*THE + FCI(K)*COSPSI(K) -FSI(K)*SINPSI(K)
      FYUI(K) = -FRI(K)*PHI + FCI(K)*SINPSI(K) + FSI(K)*COSPSI(K)
      FZUI(K) = -FRI(K)
      GO TO 45
  120 CONTINUE
      FRXU(K)=-FRI(K)*T(3,1)
      FRYU(K)=-FRI(K)*T(3,2)
      FRZU(K)=-FRI(K)*T(3,3)
      FCXU(K)=FCI(K)*(T(1,1)*COSAC(K)+T(2,1)*COSBC(K))
      FCYU(K)=FCI(K)*(T(1,2)*COSAC(K)+T(2,2)*COSBC(K))
      FCZU(K)=FCI(K)*(T(1,3)*COSAC(K)+T(2,3)*COSBC(K))
      FSXU(K)=FSI(K)*(-T(1,1)*COSBC(K)+T(2,1)*COSAC(K))
      FSYU(K)=FSI(K)*(-T(1,2)*COSBC(K)+T(2,2)*COSAC(K))
      FSZU(K)=FSI(K)*(-T(1,3)*COSBC(K)+T(2,3)*COSAC(K))
      FXUI(K)=FRXU(K)+FCXU(K)+FSXU(K)
      FYUI(K)=FRYU(K)+FCYU(K)+FSYU(K)
      FZUI(K)=FRZU(K)+FCZU(K)+FSZU(K)
  45  CONTINUE
C      ALIGNING TORQUE CALCUIATIONS
C     OVER-TURNING MOMENT CALCULATICNS
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C
      DO 4280 K=1,2
      ALTQ(K)=AFK1*FRI(K)*FSI(K)+SIGN(1.   ,FSI(K))*FSI(K)*FSI(K)  *AFK2
     1  +SIGN(1.   ,PHICGI(K))*FRI(K)*SQRT(ABS(PHICGI(K)))  *AFK3
      OTM(K)=FRI(K)*(OFC1*FSI(K)+OFC2*FSI(K)*ABS(PHICGI(K))
     1       +OFC3*PHICGI(K))
      IF(IDULTR.EQ.1) GO TO 4280
      KK= K+2
      ALTQ(KK)=ARK1*FRI(KK)*FSI(KK)+SIGN(1.   ,FSI(KK))*FSI(KK)*FSI(KK)
     1*ARK2
     1  +SIGN(1.   ,PHICGI(KK))*FRI(KK)*SQRT(ABS(PHICGI(KK)))  *ARK3
      OTM(KK)=FRI(KK)*(ORC1*FSI(KK)+OFC2*FSI(KK)*ABS(PHICGI(KK))+ORC3
     1  *PHICGI(KK))
 4280 CONTINUE
C     DUAL TIRES ON SOLID REAR AXLE
C                  IDULTR = 0, NC DUALS
C                         = 1, DUALS
C
      IF(IDULTR.EQ.1) CALL DUAL
C
      SALTQ=ALTQ(1)+ALTQ(2)+ALTQ(3)+AITQ(4)
      FOTM=OTM(1)+OTM(2)
      ROTM=OTM(3)+OTM(4)
C  AERODYNAMIC FORCES AND MOMENTS - SFXS,SFYS,SFZS,SNPHIS,SNTHES,SNPSIS
C
      IF(IAERO.EQ.1) CALL AERODY
C
      SFXU=FXU1+FXU2+FXU3+FXU4+FXU5+FXU6+SFXS
      SFYU=FYU1+FYU2+FYU3+FYU4+FYU5+FYU6+SFYS
C ***** COMPUTATION OF MOMENTS*******
      ZFDEL1=ZF+DEL1
      ZFDEL2=ZF+DEL2
      ZRDEL3=ZR+DEL3
      ZRDEL4=ZR+DEL4
      TFPHIF=TFO2*PHIF
      TRPHIR=TRO2*PHIR
C**** LET HCOSG(K)= H(K)*COS GAMMA*H(K)
      DO 12 K=1,4
      HCOSG(K)=    H(K)*COABGH(3,K)
   12 CONTINUE
C**** COMPUTE MOMENTS 8=SFSR  9=IFSR  10=IFIR  *****
      IF(IAX-1) 8,9,10
    8 SNPHIU=-(FYUI(1)+FYUI(2))*ZFDEL1-(FYUI(3)+FYUI(4))*ZRDEL3
      SNTHEU=FXUI(1)*(ZFDEL1+TFPHIF+HCOSG(1))
     1      +FXUI(2)*(ZFDEL1-TFPHIF+HCOSG(2))
     1      +FXUI(3)*(ZRDEL3+TRPHIR+HCOSG(3))
     1      +FXUI(4)*(ZRDEL3-TRPHIR+HCOSG(4))
C     MOMENTS ABOUT SOLID FRCNT AXLE
      SNPHIF=FZUI(1)*(TFO2+   H(1)*COABGH(2,1))-FZUI(2)*(TFO2-
     1    H(2)*COABGH(2,2))-FYUI(1)*(TFPHIF+HCOSG(1))+
     1  FYUI(2)*(TFPHIF-HCOSG(2))+FOTM
C     MOMENTS ABOUT SOLID REAR AXLE
   13 SNPHIR=FZUI(3)*(TRO2+   H(3)*COABGH(2,3))-
     1  FZUI(4)*(TRO2-   H(4)*COABGH(2,4))
     1  -FYUI(3)*(TRPHIR+HCOSG(3))
     1 +FYUI(4)*(TRPHIR-HCOSG(4))+ROTM
      GO TO 11
    9 SNPHIU=-FYUI(1)*(ZFDEL1+HCOSG(1)-HFC)
     1  -FYUI(2)*(ZFDEL2+HCOSG(2)-HFC)
     1  -(FYUI(3)+FYUI(4))*ZRDEL3+FOTM
```

```
      SNTHEU=FXUI(1)*(ZFDEL1+HCOSG(1))+FXUI(2)*(ZFDEL2+HCOSG(2))
     1  +FXUI(3)*(ZRDEL3+TRPHIR+HCOSG(3))+FXUI(4)*(ZRDEL3-TRPHIR+
     1  HCOSG(4))
      GO TO 13
   10 SNPHIU=-FYUI(1)*(ZFDEL1+HCOSG(1)-HFC)-FYUI(2)*(ZFDEL2+HCOSG(2)
     1 -HFC)-FYUI(3)*(ZRDEL3+HCOSG(3)-HRC)
     1  -FYUI(4)*(ZRDEL4+HCOSG(4)-HRC)
     1  +FOTM+ROTM
      SNTHEU=FXUI(1)*(ZFDEL1+HCOSG(1))+FXUI(2)*(ZFDEL2+HCOSG(2))
     1  +FXUI(3)*(ZRDEL3+HCOSG(3))+FXUI(4)*(ZRDEL4+HCOSG(4))
   11 CONTINUE
      SNPSIU=FYUI(1)*(A+H(1)*COABGH(1,1))+FYUI(2)*(A+H(2)*COABGH(1,2))
     1 -FYUI(3)*(B-H(3)*COABGH(1,3))-FYUI(4)*(B-H(4)*COABGH(1,4))
     1 -FXUI(1)*(TFO2+H(1)*COABGH(2,1))+FXUI(2)*(TFO2-H(2)*
     1 COABGH(2,2))-FXUI(3)*(TRO2+H(3)*COABGH(2,3))+FXUI(4)*(TRO2-
     1     H(4)*COABGH(2,4))+SALTQ
      SNTHEU = SNTHEU + SNTHES
      SNPHIU = SNPHIU + SNPHIS
      SNPSIU = SNPSIU + SNPSIS
      IF(IDULTR.NE.1) GO TO 14
      SNPSIU = SNPSIU - FYU5*(B-H(3)*COABGH(1,3)) -
     1 FYU6*(B-H(4)*COABGH(1,4)) + (FXU3-FXU4)*(TRO2-TIRO2) -
     1 FXU5*(TORO2 + H(3)*COABGH(2,3))+ FXU6*(TORO2 - H(4)*COABGH(2,4))
      SNTHEU = SNTHEU - (FXU3-FXU4)*(TRO2-TIRO2)*PHIR +
     1 FXU5*(ZRDEL3+TIRO2*PHIR + HCOSG(3))+ FXU6*(ZRDEL3-TIRO2*PHIR +
     1 HCOSG(4))
      SNPHIU = SNPHIU - (FYU5+FYU6)*ZRDEL3
      SNPHIR=2.0*(FZUI(3)*(TRO2+H(3)*COABGH(2,3))
     1   -FZUI(4)*(TRO2-H(4)*COABGH(2,4)))
     2  -FYUI(3)*(TIRO2*PHIR+HCOSG(3)) + FYUI(4)*(TIRO2*PHIR-HCOSG(4))
     3  - FYU5*(TORO2*PHIR+HCOSG(3)) + FYU6*(TORO2*PHIR-HCOSG(4))
14    CONTINUE
C***** INERTIAS AND GAMMAS ******
      ZFDL1=ZFDEL1**2
      ZFDL2=ZFDEL2**2
      ZRDL3=ZRDEL3**2
      ZRDL4=ZRDEL4**2
      GO TO (31,32),IAX
C     SOLID FRONT AND REAR
      AIXP=AMUF*ZFDL1+AMUR*ZRDL3                                        E
      AIYP=AIXP
      AIXZP=AMUF*A*ZFDEL1-AMUR*B*ZRDEL3                                 E
      GAM2=AMUF*ZFDEL1+AMUR*ZRDEL3                                      E
      GAM3=GAM2
      GAM4=0.                                                           E
      GAM5=AMUF*A*A+AMUR*B*B                                            E
      GAM6=2.*AMUF*DEL1DT+2.*AMUR*DEL3DT                                E
      GAM7=2.*AMUF*DEL1DT*ZFDEL1+2.*AMUR*DEL3DT*ZRDEL3                  E
      GAM8=0.                                                           E
      GAM9=AMUF*2.*A*DEL1DT-AMUR*2.*B*DEL3DT                            E
      GO TO 33
   31 CONTINUE
C     IND FRONT SOLID REAR
      AIXP=AMUF/2.*(ZFDL1+ZFDL2)+AMUR*ZRDL3                             F
      AIYP=AIXP
      AIXZP=AMUF*A/2.*(ZFDEL1+ZFDEL2)-AMUR*B*ZRDEL3                     F
      GAM2=AMUF*(ZF+(DEL1  +DEL2)/2.)+AMUR*ZRDEL3                       F
      IF(PARAM(276).EQ.11.)GAM2= AMUF*ZF + AMUR*ZR
      IF(PARAM(276).EQ.8.)GAM2 = AMUF*ZF + AMUR*ZR
      GAM3=GAM2
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      GAM4=AMUF*TF/4.*(DEL1  -DEL2)                                    F
      GAM5=AMUF*(A*A-TFO2**2)+AMUR*B*B                                 F
      GAM6=AMUF*(DEL1DT+DEL2DT)+2.*AMUR*DEL3DT                         F
      GAM7=AMUF*(ZF*(DEL1DT+DEL2DT)+DEL1  *DEL1DT+DEL2*DEL2DT)
     1 +2.*AMUR*ZRDEL3*DEL3DT                                          F
      GAM8=AMUF*TFO2*(DEL1DT-DEL2DT)                                   F
      GAM9=AMUF*A*(DEL1DT+DEL2DT)-2.*AMUR*B*DEL3DT                     F
      IF(PARAM(276).EQ.11.) GO TO 131
      IF(PARAM(276).NE.10) GO TO 130
  131 CONTINUE
      GAM4 = 0.
      GAM5 = 0.
      GAM6 = 0.
      GAM7 = 0.
      GAM8 = 0.
      GAM9 = 0.
  130 CONTINUE
      GO TO 33
  32  CONTINUE
C     IND FRONT AND REAR
      AIXP=AMUF/2.*(ZFDL1+ZFDL2)+AMUR/2.*(ZRDL3+ZRDL4)                 G
      AIYP=AIXP
      AIXZP=AMUF*A/2.*(ZFDEL1+ZFDEL2)-AMUR*B/2.*(ZRDEL3+ZRDEL4)        G
      GAM2=AMUF*(ZF+(DEL1  +DEL2)/2.)+AMUR*(ZR+(DEL3  +DEL4)/2.)       G
      GAM3=GAM2
      GAM4=AMUF*TF/4.*(DEL1  -DEL2)+AMUR*TR/4.*(DEL3  -DEL4)           G
      GAM5=AMUF*(A*A-TFO2**2)+AMUR*(B*B-TRO2**2)                       G
      GAM6=AMUF*(DEL1DT+DEL2DT)+AMUR*(DEL3DT+DEL4DT)                   G
      GAM7=AMUF*(ZF*(DEL1DT+DEL2DT)+DEL1  *DEL1DT+DEL2*DEL2DT)
     1 +AMUR*(ZR*(DEL3DT+DEL4DT)+DEL3  *DEL3DT+DEL4*DEL4DT)
      GAM8=AMUF*TFO2*(DEL1DT-DEL2DT)+AMUR*TRO2*(DEL3DT-DEL4DT)          G
      GAM9=AMUF*A*(DEL1DT+DEL2DT)-AMUR*B*(DEL3DT+DEL4DT)               G
  33  CONTINUE
C     CALCULATION OF STEER AND BRAKE COMMANDS DONE NEXT
      CALL STRBRK
C
C *********************************************************************
C
      IF(NBMP.EQ.0) GO TO 8499
      XI(1) = X +A*CPS - TFO2*SPS
      XI(2) = X +A*CPS + TFO2*SPS
      XI(3) = X -B*CPS - TRO2*SPS
      XI(4) = X -B*CPS + TRO2*SPS
      NUMBR = NUMBR + 1
      DO 8498 I=1,4
      DELX(I)=GETDEL(XI,I,PARAM(200),NBMP)
      GETDL = GETDL + DELX(I)
 8498 CONTINUE
 8499 CONTINUE
      PTB1=PTBR
      PTB2=PTBR
      AKK1=1.0
      AKK2=1.0
      IF(PARAM(60).EQ.1.0)GO TO 4334
      CALL PTBAK(BETA1,FR1,AKK1,PTB1)
      CALL PTBAK(BETA2,FR2,AKK2,PTB2)
 4334 CONTINUE
      IF(SWMT.LE.0.) GO TO 4333
      FXS1 = (FXU1-FZU1*THS1)*COSPS1+(FYU1+FZU1*PHISA1)*SINPS1
      FXS2 = (FXU2-FZU2*THS2)*COSPS2+(FYU2+FZU2*PHISA2)*SINPS2
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      FYS1=(FYU1+FZU1*PHISA1)*COSPS1-(FXU1-FZU1*THS1)*SINPS1
      FYS2=(FYU2+FZU2*PHISA2)*COSPS2-(FXU2-FZU2*THS2)*SINPS2
      AMT1 = -(YSA1-H(1)          *PSO1)*FXS1-PTB1*COSPS1*FYS1
      AMT2 = -(YSA2+H(2)          *PSO2)*FXS2-PTB2*COSPS2*FYS2
 4333 CONTINUE
      AMT1 = SWMT*AMT1
      AMT2 = SWMT*AMT2
C     CALCULATION OF ANTI PITCH AND ROLL FORCES
C     FOR SOLID AXLE DEL3 IS REAR AXLE VERTICAL ROLL CENTER
C     DL3S AND DL4S ARE REAR WHEEL SUSPENSION DEFLECTIONS
      AP1 = (CP0F + CP1F*DL1S + CP2F*DL1S*DL1S) * FXUI(1)
      AP2 = (CP0F + CP1F*DL2S + CP2F*DL2S*DL2S) * FXUI(2)
      AP3 = (CP0R + CP1R*DL3S + CP2R*DL3S*DL3S) * (FXUI(3)+FXU5)
      AP4 = (CP0R + CP1R*DL4S + CP2R*DL4S*DL4S) * (FXUI(4)+FXU6)
      AR1 = -(CR0F + CR1F*DL1S + CR2F*DL1S*DL1S) * FYUI(1)
      AR2 =  (CR0F + CR1F*DL2S + CR2F*DL2S*DL2S) * FYUI(2)
      AR3 = -(CR0R + CR1R*DL3S + CR2R*DL3S*DL3S) *(FYUI(3)+FYU5)
      AR4 =  (CR0R + CR1R*DL4S + CR2R*DL4S*DL4S) *(FYUI(4)+FYU6)
      FSWF=0.5*AMS*G*B/(A+B)
      FSWR=0.5*AMS*G*A/(A+B)
      ANTI1=AP1+AR1-FBS1
      ANTI2=AP2+AR2-FBS2
      ANTI3=AP3+AR3-FBS3
      ANTI4=AP4+AR4-FBS4
C
C ***********************************************************************
C
C     SAMPLE VALUES TO CALCUIATE THE COMPARISON VARIABLES
      CALL CVCALC
C
C ***********************************************************************
C     PREPARATION OF VARIABLES TO BE OUTPUT ON D/A CONVERTERS
      TM1=1./SM
      TEMP=GAM2*TM1
      IOUT(01)=-TEMP
      TEMP=GAM1*TM1
      IOUT(02)=TEMP
      IOUT(03)=-TEMP
      TEMP=GAM2*TM1
      IOUT(04)=-TEMP
      TM1=1./(AIX+AIXP)
      TEMP=GAM3*TM1
      IOUT(05)=TEMP
      TEMP=(AIXZ+AIXZP)*TM1
      IOUT(06)=TEMP
      TEMP=GAM7*TM1
      IOUT(07)=-TEMP
      TEMP=GAM4*TM1
      IOUT(08)=-TEMP
      TEMP=SCALE*TM1
      IOUT(09)=TEMP
      TM1=1./(AIY+AIYP)
      TEMP=GAM2*TM1
      IOUT(10)=TEMP
      TEMP=AIXZ*TM1
      IOUT(11)=TEMP
      TEMP=AIXZP*TM1
      IOUT(12)=TEMP
      TEMP=GAM7*TM1
      IOUT(13)=-TEMP
```

```
TEMP=GAM4*TM1
IOUT(14)=-TEMP
TEMP=SCALE*TM1
IOUT(15)=TEMP
TM1=1./(AIZ+AIZP)
TEMP=(AIXZ+AIXZP)*TM1
IOUT(16)=-TEMP
TEMP=GAM1*TM1
IOUT(17)=-TEMP
TEMP=GAM4*TM1
IOUT(18)=TEMP
TM1=1./(    AIWR+AID*ARBR*ARBR/4.)
TM2=1./(    AIWF+AIDF*ARFBR*ARFBR/4.)
IOUT(19)=SPINH1/MPHIPS
IOUT(20)=SPINH2/MPHIPS
TEMP=FR3*H(3)*H(3)*SL(3)*TM1/UG3P
IF(IDULTR.EQ.1) TEMP=2.0*TEMP
IOUT(21)=TEMP
TEMP=FR4*H(4)*H(4)*SL(4)*TM1/UG4P
IF(IDULTR.EQ.1) TEMP=2.0*TEMP
IOUT(22)=TEMP
TEMP=FR1*H(1)*H(1)*SL(1)*TM2/UG1P
IOUT(23)=TEMP
TEMP=FR2*H(2)*H(2)*SL(2)*TM2/UG2P
IOUT(24)=TEMP
TEMP = SL(1) + SEP(1)
TEMP=( FR1*H(1)*TEMP+TQFBR)*TM2
IOUT(33)=-TEMP
TEMP = SL(2) + SEP(2)
TEMP=( FR2*H(2)*TEMP+TQFBL)*TM2
IOUT(34)=-TEMP
TEMP = SL(3) + SEP(3)
IF(IDULTR.EQ.1) TEMP=2.0*TEMP
TEMP=( FR3*H(3)*TEMP+TQRBR)*TM1
IOUT(35)=-TEMP
TEMP = SL(4) + SEP(4)
IF(IDULTR.EQ.1) TEMP=2.0*TEMP
TEMP=( FR4*H(4)*TEMP+TQRBL)*TM1
IOUT(36)=-TEMP
TEMP = (AMT2 + ALTQ(2)) / AIFW - RDT
IOUT(25) = -TEMP*PARAM(175)
TEMP=DELSWC
IOUT(26)=TEMP
TM1=1./SM
TEMP=(-GAM6*Q+SFXU)*TM1
IOUT(27)=TEMP
TEMP=(GAM6*P+SFYU)*TM1
IOUT(28)=TEMP
TEMP=(2.*(FSWF+FSWR)-SFZS)/AMS
IOUT(29)=TEMP
TEMP=(1./(AIX+AIXP))*(Q*R*(AIY-AIZ+AIXP)+SNPHIU)
IOUT(30)=TEMP
TEMP=(1./(AIY+AIYP))*(P*R*(AIZ-AIX-AIYP)+SNTHEU)
IOUT(31)=TEMP
TEMP=(1./(AIZ+AIZP))*(P*Q*(AIX-AIY-GAM5)+GAM8*Q
1 +GAM9*P+SNPSIU)
IOUT(32)=TEMP
TEMP=ANTI1
IOUT(38)=TEMP-FSARF
TEMP=ANTI2
```

```
      IOUT(39)=TEMP-FSALF
      TEMP=ANTI3
      IOUT(40)=TEMP-FSARR
      TEMP=ANTI4
      IOUT(41)=TEMP-FSALR
C******** SPLIT FRONT AXLE ********
      TM1 =2.*HFC/TF
      TEMP=(2./AMUF)*(FZU1-FYU1*TM1+FSWF)*PARAM(175)
      IOUT(42)=TEMP
      TEMP=(2./(1000.*AMUF))*(FZU2+FYU2*TM1+FSWF)*PARAM(175)
      IOUT(43)=TEMP
C******** SOLID REAR AXLE *******
      TEMP=(1./AMUR)*(FZU3+FZU4)
      IF(IDULTR.EQ.1) TEMP = 2.0*TEMP
      TEMP=(TEMP+(2.*FSWR/AMUR))*PARAM(175)
      IOUT(44)=TEMP
      TEMP=(1./(10.*AIR))*(SNPHIR)*PARAM(175)
      IOUT(45)=TEMP
      IF(IAX.LE.1) GO TO 7719
C******** SPLIT REAR AXLE ******
      TM1 = 2.*HRC/TR
      TM1 = TAN(TM1)
      TEMP=(2./AMUR)*(FZU3-FYU3*TM1+FSWR)*PARAM(175)
      IOUT(44)=TEMP
      TEMP=(2./(1000.*AMUR))*(FZU4+FYU4*TM1+FSWR)*PARAM(175)
      IOUT(45)=TEMP
      GO TO 7720
 7719 IF(IAX.EQ.1) GO TO 772C
C******** SOLID FRONT AXLE ********
      TEMP=(1./AMUF)*(FZU1+FZU2+2.*FSWF)*PARAM(175)
      IOUT(42)=TEMP
      TEMP=(1./(10.*AIF))*(SNPHIF)*PARAM(175)
      IOUT(43)=TEMP
 7720 CONTINUE
      TEMP = (AMT1 + ALTQ(1)) / AIFW - RDT
      IOUT(46) = -TEMP*PARAM(175)
      DO 3147 I=1,48
      DACO(I)=BVALUE(DACPLA(I))/SCALDC(I)
      SDACO=DACO(I)
      DACO(I)=AMAX1(-.9995,(AMIN1(.9995,DACO(I))))
      IF(SDACO.EQ.DACO(I)) GC TO 8317
      IDACK=IDACK+1
      IF(IDACK.GT.10) IDACK=10
      IERDAC(IDACK) = I
      TERDAC(IDACK)=TIME
 8317 CONTINUE
 3147 CONTINUE
C     DATA COLLECTION FOR TRACK OPTICN
      IF(TIME.LT.(ONTIM-.00001)) GO TC 8185
      IF(TIME.GT.OFFTIM) GO TO 8185
      IKEEP=IKEEP+1
      IF(IKEEP.NE.ISAMP) GO TO 8185
      IKEEP=0
      DO 8199 I=1,ITRA
      J=ITRAA(I)
      JIN=JIN+1
      IF(JIN.GT.1999) JIN=1999
      ATRACK(JIN)=BVALUE(J)
 8199 CONTINUE
 8185 CONTINUE
      RETURN
      END
```

H-2.1.8 LFRIC

Presented here is the Fortran listing for the LFRIC subprogram. The following calculations are performed in LFRIC:

1. Lateral coefficient of friction.

2. Circumferential tire force.

3. Lateral tire force.

4. Circumferential and lateral components of the tire force on the wheel.

```
      SUBROUTINE LFRIC
C     THIS SUBROUTINE CALCULATES THE LATERAL FRICTION COEFF.
C
C FUNCTION:  AMUI-MAXIMUM LATERAL FRICTION COEFFICIENT
C
C INPUTS:    B1-(PARAM(85)),LOAD TERM COEFFICIENT OF LATERAL FRICTION
C            COEFFICIENT (1/LB)
C            B2-(PARAM(86)),VELOCITY TERM COEFFICIENT OF LATERAL
C            FRICTION COEFFICIENT (1/MPH)
C            B3-(PARAM(87)),CONSTANT TERM (UNITY)
C            B4-(PARAM(88)),QUADRATIC LOAD TERM(1/LB**2)
C            FRI-RADIAL TIRE FORCE (POUNDS)
C            CVI-VELOCITY OF VEHICLE (MPH)
C
C OUTPUT:    AMUI-MAXIMUM LATERAL FRICTION COEFFICIENT (UNITY)
C
      COMMON/TYRTBL/ FRTBL(7),B3TBL(7),A0TBL(7)
      COMMON/PAUL/ D1,D2,D3,D4,SFYU,TMP,SNPHIU,SNTHEU,SNPSIU,
     1QDT,PDT, RDT ,UDT,VDT,WDT,PHIDT,THEDT,PSIDT,XDT,YDT,ZDT,
     1 AKK1,AKK2,                                THS1,THS2,
     1AMT1,AMT2,SN,SFXU,BTVDT,ETAX,ETAL,
     1 ZIP(4),PHII(4),
     1           U1I(4),BAMI(4),MUP(4),SAMI(4),FI(4),FXUI(4),FYUI(4),GI(4),
     1           ALFI(4),BETIP(4),BETIBR(4),SLIPI(4),AM1I(4),AM2I(4),UOI(4),
     1           FCI(4),FCIMAX(4),FSI(4),
     1           ABI(4),BETAI(4),AMUI(4),SNI(4),RMI(4),GBI(4),FRIBR(4),
     1           RWZI(4),ZI(4),FRI(4),          UI(4),VI(4),WI(4),UGI(4),
     1           VGI(4),SINPSI(4),PSII(4),COSPSI(4),UGIP(4),PHICGI(4),CVI(4)
     1,ALTQ(4),OTM(4),SALTQ,FCTM,ROTM
     1,AP1,AP2,AP3,AP4,AR1,AR2,AR3,AR4,ANTI1,ANTI2,ANTI3,ANTI4
     1,DLIS(4),ZIMX(4),FBS1,FBS2,FBS3,FBS4
     1,PHIDMX
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      COMMON/COMBLK/ SM,CIP,CIVP,RZF,RZR,A2T,CA20,CA23,TSFO2,
     1      TRO2,TFO2,TSO2,G,THRD,TWN7,R2T,RA20,RA23
      COMMON/SPLTAX/ SPSR3,SPSR4,IAX
      COMMON/CACATO/EPSK1,EPSK2,FEE1,FEE2,THE1,THE2
      COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI
      EQUIVALENCE
     1   (PARAM(34),CA0)      , (PARAM(35),CA1)    , (PARAM(36),CA2)     ,
     1   (PARAM(37),CA3)      , (PARAM(38),CA4)    , (PARAM(39),AISW)    ,
     1   (PARAM(85),B1)       , (PARAM(86),B2)     , (PARAM(87),B3),
```

```
     1 (PARAM(88),B4),          (PARAM( 89),DEL1DN),(PARAM( 90),DEL2DN),  LFRI 470
     1 (PARAM(242),AKCF),(PARAM(243),AKCR),(PARAM(244),AKSR)  ,           LFRI 480
     1   (PARAM(290),ROT),(PARAM(291),RA0),(PARAM(292),RA1),              LFRI 490
     1   (PARAM(293),RA2),(PARAM(294),RA3),(PARAM(295),RA4)               LFRI 500
      EQUIVALENCE (PARAM(245),RB1),(PARAM(246),RB2)                       LFRI 510
     1,           (PARAM(247),RB3),(PARAM(248),RB4)                       LFRI 520
      IF(PARAM(209).EQ.1.)GO TO 500                                       LFRI 550
      DO 60 K=1,2                                                         LFRI 560
      KK = K + 2                                                          LFRI 570
      AMUI(K)=(B1*FRI(K)+B2*CVI(K)+B3+B4*FRI(K)*FRI(K))*SNI(K)            LFRI 580
      RMI(K) = FRI(K) * AMUI(K)                                           LFRI 590
      FRIBR(K) = AMIN(FRI(K),A2T)                                         LFRI 600
C     ALFI IS THE DENOMINATOR FOR THE BETA BAR CALCULATION                LFRI 610
      ALFI(K) = CA1*FRIBR(K)*(FRIBR(K) - CA2) - CA20                      LFRI 620
      IF(ALFI(K)/CA2.GE.0.) ALFI(K) =-1.0E-10                             LFRI 630
      BETIP(K) = CA23*(CA4-FRIBR(K))*FRIBR(K)*PHICGI(K)/(CA4*ALFI(K))     LFRI 680
      IF(RMI(K).EQ.0.) GO TO 610                                          LFRI 690
      BETIBR(K) = ALFI(K)*(BETAI(K) + BETIP(K))/(CA2*RMI(K))              LFRI 700
      GO TO 710                                                           LFRI 710
  610 BETIBR(K) = 0.                                                      LFRI 720
  710 CONTINUE                                                            LFRI 730
      AMUI(KK) = (RB3 + RB1*FRI(KK) + RB2*CVI(KK) + RB4*FRI(KK)*FRI(KK))  LFRI 740
     1 *SNI(KK)                                                           LFRI 750
      RMI(KK) = FRI(KK) * AMUI(KK)                                        LFRI 760
      FRIBR(KK) = AMIN(FRI(KK),R2T)                                       LFRI 770
      ALFI(KK) = RA1*FRIBR(KK)*(FRIBR(KK) - RA2) - RA20                   LFRI 780
      IF(ALFI(KK)/RA2.GE.0.) ALFI(KK) = 1.0E-10                           LFRI 790
      BETIP(KK)=RA23*(RA4-FRIBR(KK))*FRIBR(KK)*PHICGI(KK)/(RA4*ALFI(KK))  LFRI 820
      IF(RMI(KK).EQ.0.) GO TO 630                                         LFRI 830
      BETIBR(KK) = ALFI(KK)*(BETAI(KK) + BETIP(KK)) / (RA2*RMI(KK))       LFRI 840
      GO TO 730                                                           LFRI 850
  630 BETIBR(KK) = 0.                                                     LFRI 860
  730 CONTINUE                                                            LFRI 870
   60 CONTINUE                                                            LFRI 880
      GO TO 510                                                           LFRI 890
  500 CONTINUE                                                            LFRI 900
      DO 521 K = 1,2                                                      LFRI 910
      KK = K + 2                                                          LFRI 920
      AMUI(K) = XINT(FRI(K),FRTBL,B3TBL,7)*SNI(K)                         LFRI 930
      AMUI(KK) = XINT(FRI(KK), FRTBL, B3TBL,7)*SNI(KK)                    LFRI 940
      ALFI(K) = -XINT(FRI(K),FRTBL,A0TBL,7)                               LFRI 950
      ALFI(KK) = -XINT(FRI(KK), FRTBL, A0TBL,7)                           LFRI 960
  521 CONTINUE                                                            LFRI 970
      DO 520 K=1,4                                                        LFRI 980
      RMI(K) = FRI(K) * AMUI(K)                                           LFRI 990
      BETIP(K) = 0.                                                       LFRI1030
      BETIBR(K) = 0.                                                      LFRI1040
      IF(RMI(K) .EQ.0.) GO TO 530                                         LFRI1050
      BETIBR(K) = ALFI(K)*(BETAI(K) + BETIP(K))/RMI(K)                    LFRI1060
  530 CONTINUE                                                            LFRI1070
  520 CONTINUE                                                            LFRI1080
  510 CONTINUE                                                            LFRI1090
      DO 11 K=1,4                                                         LFRI1100
      ABI(K) = ABS(BETIBR(K))                                             LFRI1110
      IF(ABI(K).GE.3.) GO TO 10                                           LFRI1120
      GBI(K) = BETIBR(K)*(1.-THRD*ABI(K)+TWN7*BETIBR(K)**2)               LFRI1130
      GO TO 80                                                            LFRI1140
   10 GBI(K) = BETIBR(K)/ABI(K)                                           LFRI1150
   80 CONTINUE                                                            LFRI1160
```

```
C
C FUNCTION:  FCSI-SIDE FORCE SHAPING AS A FUNCTION OF SLIP
C
C INPUTS:    SAMI- SIDE-SLIP ANGLE (DEGREES)
C            GAMF-SIDE FORCE SHAPING FUNCTION AS A FUNCTION OF
C            SLIP (UNITY)
C            AFA-BRAKING SLIP (UNITY)
C            NFA-NUMBER OF DATA PCINTS
C
C OUTPUTS:   FCSI-LINEARLY ITERPOIATED SIDE FORCE SHAPING FUNCTION
C
      BAMI(K) = BETAI(K) + BETIP(K)
      SAMI(K) = BAMI(K)*57.29578
       FI(K) = FCSI(SAMI(K),SLIPI(K))
      XX = ABS(AMUI(K)*GBI(K))
      ASNBET = ABS(SIN(BETAI(K)))*SNI(K)
      GO TO (100,100,110,110),K
  100 XXX = (XX - (XX-PARAM(206)*ASNBET)*FI(K))*SIGN(1.,GBI(K))
      GO TO 120
  110 XXX = (XX - (XX-PARAM(207)*ASNBET)*FI(K))*SIGN(1.,GBI(K))
  120 CONTINUE
C            PARAM(306) TO (309) CIRCUM. FRICTION COEF.
      FSI(K) = FRI(K) * XXX
   11 CONTINUE
      RETURN
      END
```

H-2.1.9 CFRIC

Presented here is the Fortran listing for the CFRIC subprogram. Calculation of the circumferential friction coefficient is performed in this subprogram.

```
C     SUBROUTINE CFRIC
      SUBROUTINE CFRIC
C***********************************************************************
C     THIS SUBPROGRAM CALCULATES THE CIRCUMFERENTIAL FRICTION
C     COEFFICIENT
C***********************************************************************
C            MUP- PEAK BRAKING COEF. OF FRICTION
C            MUS- SLIDING COEF. OF FRICTION
C            SII- SLIP RATIO AT WHICH PEAK BRAKING
C                 COEF. OF FRICTION OCCURS
C
C            SNI- RATIO OF SIM. VEHICLE SKID NUMBER SURFACE
C                  TO TIRE DATA SKID NUMBER SURFACE
C
C FUNCTION:   AM1I-RISE SLOPE OF UXI VS. WHEEL SLIP
C
C            SAMI- SLIP ANGLE (DEGREES)
C            SI1-(PARAM(182),UNITY)
C            SI2-(PARAM(183),UNITY)
C            SI3-(PARAM(184),UNITY)
C            SI4-(PARAM(185),UNITY)
C
C            OUTPUT:   AM1I - UNITY
      COMMON/CFRC/ SL(4),SEP(4),CFCOEF(4),ARPS(4)
      COMMON/PAUL/ D1,D2,D3,D4,SFYU,TMP,SNPHIU,SNTHEU,SNPSIU,
     1QDT,PDT, RDT ,UDT,VDT,WDT,PHIDT,THEDT,PSIDT,XDT,YDT,ZDT,
     1 AKK1,AKK2,                                  THS1,THS2,
     1AMT1,AMT2,SN,SFXU,BTVDT,ETAX,ETAL,
     1 ZIP(4),PHII(4),
     1       U1I(4),BAMI(4),MUP(4),SAMI(4),FI(4),FXUI(4),FYUI(4),GI(4),
     1       ALFI(4),BETIP(4),BETIBR(4),SLIPI(4),AM1I(4),AM2I(4),U0I(4),
     1       FCI(4),FCIMAX(4),FSI(4),
     1       ABI(4),BETAI(4),AMUI(4),SNI(4),RMI(4),GBI(4),FRIBR(4),
     1       RWZI(4),ZI(4),FRI(4),        UI(4),VI(4),WI(4),UGI(4),
     1       VGI(4),SINPSI(4),PSII(4),COSPSI(4),UGIP(4),PHICGI(4),CVI(4)
     1,ALTQ(4),OTM(4),SALTQ,FOTM,ROTM
     1,AP1,AP2,AP3,AP4,AR1,AR2,AR3,AR4,ANTI1,ANTI2,ANTI3,ANTI4
     1,DLIS(4),ZIMX(4),FBS1,FBS2,FBS3,FBS4
     1,PHIDMX
      COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      REAL*4 MUSF,MUSR
      REAL*4 MUS(2),APF(2),APR(2),IOUT(48),MUP,SII(4)
      EQUIVALENCE (PARAM(182),SII(1)),(PARAM(351),IOUT(1))
      EQUIVALENCE (PARAM(202),APF(1)),(PARAM(204),APR(1)),
     1   (PARAM(206),MUS(1))
      EQUIVALENCE  (APF(1),APF1),(APR(1),APR1),
     1             (APF(2),APF2),(APR(2),APR2)
      EQUIVALENCE (BCON,PARAM(208))
      DO 13 K=1,2
      KK=K+2
      MUP(K)  = APF1 + APF2*FRI(K)
      MUSF = MUS(1) + PARAM(210)*FRI(K)
```

```
      MUSF = MUSF   *ABS(COS(BETAI(K)))
      AM1I(K)  =  (MUP(K)/SII(K))*(1.  -BCON*ABS(SAMI(K)))                  CFRI 540
C **  MUS(1) EQUALS MUSF,MUS(2) EQUALS MUSR **                              CFRI 550
      IF((AM1I(K))*SII(K).LT.MUSF) AM1I(K) = MUSF/SII(K)                    CFRI 560
      IF(SLIPI(K).GT.SII(K)) GO TC 71                                       CFRI 570
      AM1I(K) = AM1I(K) * SNI(K)                                            CFRI 580
      SL(K ) = AM1I(K )
      SEP(K ) = 0.
      GO TO 72                                                              CFRI 630
 71    CONTINUE                                                             CFRI 640
      AM2I(K) =  (MUSF-(AM1I(K)*SII(K)))/(1. - SII(K))                      CFRI 650
      AM2I(K) = AM2I(K) * SNI(K)                                            CFRI 660
      SL(K ) = AM2I(K )
C OUTPUT:      U1I-VALUE OF UXI AT BRAKE SLIP = 1. (UNITY)                  CFRI 680
      U1I(K) = MUSF    * SNI(K)                                             CFRI 690
C OUTPUT:      U0I-INTERCEPT OF UXI AT BRAKE SLIP = 0 (UNITY)              CCFRI 700
      U0I(K) = U1I(K) - AM2I(K)                                             CFRI 710
      SEP(K ) = U0I(K )
 72    CONTINUE                                                             CFRI 730
      MUP(KK) = APR1 + APR2 * FRI(KK)                                       CFRI 740
      MUSR = MUS(2) + PARAM(211)*FRI(KK)
      MUSR = MUSR   *ABS(COS(BETAI(KK)))
      AM1I(KK) = (MUP(KK)/SII(KK))*(1. - BCON*ABS(SAMI(KK)))                CFRI 760
      IF((AM1I(KK))*SII(KK).LT.MUSR) AM1I(KK) = MUSR/SII(KK)                CFRI 770
      IF(SLIPI(KK).GT.SII(KK)) GO TC 76                                     CFRI 780
      AM1I(KK) = AM1I(KK) * SNI(KK)                                         CFRI 790
      SL(KK) = AM1I(KK)
      SEP(KK) = 0.
      GO TO 77                                                              CFRI 820
 76    CONTINUE                                                             CFRI 830
      AM2I(KK)= (MUSR - (AM1I(KK)*SII(KK)))/(1. - SII(KK))                  CFRI 840
      AM2I(KK) = AM2I(KK) * SNI(KK)                                         CFRI 850
      SL(KK) = AM2I(KK)
      U1I(KK) = MUSR     * SNI(KK)                                          CFRI 870
      U0I(KK) = U1I(KK) - AM2I(KK)                                          CFRI 880
      SEP(KK) = U0I(KK)
 77    CONTINUE                                                             CFRI 900
  13  CONTINUE                                                              CFRI 910
      DO 10 K=1,4
      CFCOEF(K) = SL(K)*SLIPI(K) + SEP(K)
      FCI(K) = -CFCOEF(K)*FRI(K)
      FCIMAX(K) =-FRI(K)*AM1I(K)*SII(K)                                     LFRI1440
10    CONTINUE
      RETURN                                                                CFRI 920
      END                                                                   CFRI 930
```

H-2.1.10 DUAL

Presented here is the Fortran listing for the DUAL tire subprogram. Calculation of dual rear tire digital model equations is performed in this subprogram.

```
C     SUBROUTINE DUAL
      SUBROUTINE DUAL
      COMMON/TYRTBL/ FRTBL(7),B3TBL(7),A0TBL(7)
      COMMON/DULVAR/Z3ID,Z4ID,Z5OD,Z6CD,
     1              F3RID,F4RID,F5ROD,F6ROD,
     1              U3ID,U4ID,U5OD,U6OD,
     1              V3ID,V4IL,V5OD,V6CD,
     1              W3ID,W4ID,W5OD,W6OD,
     1              UG3ID,UG4ID,UG5OD,UG6OD,
     1              VG3ID,VG4ID,VG5CD,VG6OD,
     1              UG3IDP,UG4IDP,UG5CDP,UG6ODP,
     1              S3ID,S4IL,S5OD,S6CD,
     1              CF3ID,CF4ID,CF5OD,CF6OD,
     1              AMUI3,AMUI4,AMUI5,AMUI6,
     1              ALTQ3P,AITQ4P,
     1              OTM3P,OTM4P,OTM5,OTM6
      COMMON/DUALS/IDULTR,NWHEEL,TIRO2,TORO2,TIRTOR,VBRZRP,
     1 FXU5,FXU6,FYU5,FYU6,AITQ5,ALTQ6,FSI3,FSI4,FSI5,FSI6,PPHIR
      COMMON/XBS/XB(30),NS(4,30),DELX(4),XI(4),NNN
      COMMON/PAUL/ D1,D2,D3,D4,SFYU,TMP,SNPHIU,SNTHEU,SNPSIU,
     1QDT,PDT, RDT ,UDT,VDT,WCT,PHIDT,THEDT,PSIDT,XDT,YDT,ZDT,
     1 AKK1,AKK2,                                THS1,THS2,
     1AMT1,AMT2,SN,SFXU,BTVDT,ETAX,ETAL,
     1 ZIP(4),PHII(4),
     1        U1I(4),BAMI(4),MUP(4),SAMI(4),FI(4),FXUI(4),FYUI(4),GI(4),
     1        ALFI(4),BETIP(4),BETIBR(4),SLIPI(4),AM1I(4),AM2I(4),U0I(4),
     1        FCI(4),FCIMAX(4),FSI(4),
     1        ABI(4),BETAI(4),AMUI(4),SNI(4),RMI(4),GBI(4),FRIBR(4),
     1        RWZI(4),ZI(4),FRI(4),         UI(4),VI(4),WI(4),UGI(4),
     1        VGI(4),SINPSI(4),PSII(4),COSPSI(4),UGIP(4),PHICGI(4),CVI(4)
     1,ALTQ(4),OTM(4),SALTQ,FCTM,ROTM
     1,AP1,AP2,AP3,AP4,AR1,AR2,AR3,AR4,ANTI1,ANTI2,ANTI3,ANTI4
     1,DLIS(4),ZIMX(4),FBS1,FES2,FBS3,FBS4
     1,PHIDMX
      COMMON/VARS/ P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI
      COMMON/COMBLK/ SM,CIP,CIVP,BZF,RZR,A2T,CA20,CA23,TSFO2,
     1             TRO2,TFO2,TSO2,G,THRD,TWN7,R2T,RA20,RA23
      COMMON/CFRC/ SL(4),SEP(4),CFCCEF(4),ARPS(4)
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      COMMON/ADCOUT/ DEL1DT,DEL2DT,DEL3DT,DEL1,DEL2,DEL3,PHIRD,PHIR,
     2 DELFW1,DELFW2,S1P,S2P,S3P,S4P
      REAL*4 AKTI(4),IOUT(48)
      EQUIVALENCE
     1 (PARAM(5),ZR),(PARAM(7),B),
     1(PARAM(31),RW),
     1(PARAM(79),AKTI(3)),(PARAM(80),AKTI(4)),
     1(PARAM(245),RB1),(PARAM(246),RB2),
     1(PARAM(247),RB3),(PARAM(248),RB4),
     1(PARAM(252),ARK1),(PARAM(253),ARK2),(PARAM(254),ARK3),
     1(PARAM(259),ORC0),(PARAM(260),ORC1),(PARAM(261),ORC2),
     1(PARAM(262),ORC3),(ARPS3,ARPS(3)),(ARPS4,ARPS(4))
      Z3ID=ZI(3)+TIRTOR*(PHI+PHIR)
      Z4ID=ZI(4)-TIRTOR*(PHI+PHIR)
```

```
      Z5OD=ZI(3)-TIRTOR*(PHI+PHIR)                                      DUAL 540
      Z6OD=ZI(4)+TIRTOR*(PHI+PHIR)                                      DUAL 550
      RWZD3 = RW + Z3ID
      RWZD4 = RW + Z4ID
      RWZD5 = RW + Z5OD
      RWZD6 = RW + Z6OD
      F3RID = AKTI(3)*RWZD3
      F4RID = AKTI(4)*RWZD4
      F5ROD = AKTI(3)*RWZD5
      F6ROD = AKTI(4)*RWZD6
      IF(RWZD3.LE.0.) F3RID = 0.
      IF(RWZD4.LE.0.) F4RID = 0.
      IF(RWZD5.LE.0.) F5ROD = 0.
      IF(RWZD6.LE.0.) F6ROD = 0.
      U3ID=UI(3)-TIRTOR*R                                               DUAL 640
      U4ID=UI(4)+TIRTOR*R                                               DUAL 650
      U5OD=UI(3)+TIRTOR*R                                               DUAL 660
      U6OD=UI(4)-TIRTOR*R                                               DUAL 670
      V3ID = VBRZRP + Z3ID*PPHIR                                        DUAL 680
      V4ID = VBRZRP + Z4ID*PPHIR                                        DUAL 690
      V5OD = VBRZRP + Z5OD*PPHIR                                        DUAL 700
      V6OD = VBRZRP + Z6OD*PPHIR                                        DUAL 710
      W3ID=WI(3)+TIRTOR*PPHIR                                           DUAL 720
      W4ID=WI(4)-TIRTOR*PPHIR                                           DUAL 730
      W5OD=WI(3)-TIRTOR*PPHIR                                           DUAL 740
      W6OD=WI(4)+TIRTOR*PPHIR                                           DUAL 750
      UG3ID = U3ID + THE*W3ID                                           DUAL 760
      UG4ID = U4ID + THE*W4ID                                           DUAL 770
      UG5OD = U5OD + THE*W5OD                                           DUAL 780
      UG6OD = U6OD + THE*W6OD                                           DUAL 790
      VG3ID = V3ID - PHI*W3ID                                           DUAL 800
      VG4ID = V4ID - PHI*W4ID                                           DUAL 810
      VG5OD = V5OD - PHI*W5OD                                           DUAL 820
      VG6OD = V6OD - PHI*W6OD                                           DUAL 830
      UG3IDP = UG3ID*COSPSI(3) + VG3ID*SINPSI(3)                        DUAL 840
      UG4IDP = UG4ID*COSPSI(4) + VG4ID*SINPSI(4)                        DUAL 850
      UG5ODP = UG5OD*COSPSI(3) + VG5OD*SINPSI(3)                        DUAL 860
      UG6ODP = UG6OD*COSPSI(4) + VG6OD*SINPSI(4)                        DUAL 870
      S3ID = 1. + (ARPS3*Z3ID)/UG3IDP                                   DUAL 880
      IF(S3ID.LT.(-1.).OR.S3ID.GT.1.) S3ID = SIGN(1.,S3ID)              DUAL 890
      IF(S3ID.LE.0.0001) S3ID=0.
      S4ID = 1. + (ARPS4*Z4ID)/UG4IDP                                   DUAL 900
      IF(S4ID.LT.(-1.).OR.S4ID.GT.1.) S4ID = SIGN(1.,S4ID)              DUAL 910
      IF(S4ID.LE.0.0001) S4ID=0.
      S5OD = 1. + (ARPS3*Z5OD)/UG5ODP                                   DUAL 920
      IF(S5OD.LT.(-1.).OR.S5OD.GT.1.) S5OD = SIGN(1.,S5OD)              DUAL 930
      IF(S5OD.LE.0.0001) S5OD=0.
      S6OD = 1. + (ARPS4*Z6OD)/UG6ODP                                   DUAL 940
      IF(S6OD.LT.(-1.).OR.S6OD.GT.1.) S6OD = SIGN(1.,S6OD)              DUAL 950
      IF(S6OD.LE.0.0001) S6OD=0.
      CF3ID = SEP(3) + S3ID*SL(3)
      CF4ID = SEP(4) + S4ID*SL(4)
      CF5OD = SEP(3) + S5OD*SL(3)
      CF6OD = SEP(4) + S6OD*SL(4)
      IF(PARAM(209).EQ.1.)GO TO 500
      AMUI3 = (RB3 + RB1*F3RID + RB4*F3RID*F3RID)* SNI(3)               DUAL1000
      AMUI4 = (RB3 + RB1*F4RID + RB4*F4RID*F4RID)* SNI(4)               DUAL1010
      AMUI5 = (RB3 + RB1*F5ROD + RB4*F5ROD*F5ROD)* SNI(3)               DUAL1020
      AMUI6 = (RB3 + RB1*F6ROD + RB4*F6ROD*F6ROD)* SNI(4)               DUAL1030
      GO TO 510
```

```
500 CONTINUE
    AMUI3 =  XINT(F3RID,FRTEL,B3TBL,7)*SNI(3)
    AMUI4 =  XINT(F4RID,FRTBL,B3TBL,7)  *SNI(4)
    AMUI5 =  XINT(F5ROD,FRTEL,B3TBL,7)*SNI(3)
    AMUI6 =  XINT(F6ROD,FRTEL,B3TBL,7)*SNI(4)
510 CONTINUE
    XX3=ABS(AMUI3*GBI(3))                                              DUAL1040
    XX4=ABS(AMUI4*GBI(4))                                              DUAL1050
    XX5=ABS(AMUI5*GBI(3))                                              DUAL1060
    XX6=ABS(AMUI6*GBI(4))                                              DUAL1070
    ASNBT4=ABS(SIN(BETAI(4)))*SNI(4)*PARAM(207)                        DUAL1080
    ASNBT3=ABS(SIN(BETAI(3)))*SNI(3)*PARAM(207)                        DUAL1090
    SIGNB3=SIGN(1.,GBI(3))                                             DUAL1100
    SIGNB4=SIGN(1.,GBI(4))                                             DUAL1110
    XXX3=(XX3-(XX3-ASNBT3)*FI(3))*SIGNB3                               DUAL1120
    XXX4=(XX4-(XX4-ASNBT4)*FI(4))*SIGNB4                               DUAL1130
    XXX5=(XX5-(XX5-ASNBT3)*FI(3))*SIGNB3                               DUAL1140
    XXX6=(XX6-(XX6-ASNBT4)*FI(4))*SIGNB4                               DUAL1150
    FYUI(3)=F3RID*(-PHI-CF3ID*SINPSI(3)+           COSPSI(3)*XXX3)     DUAL1160
    FYUI(4)=F4RID*(-PHI-CF4ID*SINPSI(4)+           COSPSI(4)*XXX4)     DUAL1170
    FYU5 =  F5ROD*(-PHI-CF5OD*SINPSI(3)+           COSPSI(3)*XXX5)     DUAL1180
    FYU6 =  F6ROD*(-PHI-CF6CD*SINPSI(4)+           COSPSI(4)*XXX6)     DUAL1190
    FSI3 =  F3RID*XXX3                                                 DUAL1200
    FSI4 =  F4RID*XXX4                                                 DUAL1210
    FSI5 =  F5ROD*XXX5                                                 DUAL1220
    FSI6 =  F6ROD*XXX6                                                 DUAL1230
    FXUI(3)=F3RID*(THE-CF3ID*COSPSI(3)-           SINPSI(3)*XXX3)      DUAL1240
    FXUI(4)=F4RID*(THE-CF4ID*COSPSI(4)-            SINPSI(4)*XXX4)     DUAL1250
    FXU5 =  F5ROD*(THE-CF5OD*COSPSI(3)  -         SINPSI(3)*XXX5 )     DUAL1260
    FXU6 =  F6ROD*(THE-CF6OD*COSPSI(4)  -          SINPSI(4)*XXX6)     DUAL1270
C     PHICG3=PHICG4=PHICG5=PHICG6=0.0                                  DUAL1280
    ALTQ3P=ARK1*F3RID*FSI3+SIGN(1.,FSI3)*FSI3*FSI3*ARK2                DUAL1290
   1  +SIGN(1.,PHICGI(3))*F3RID*SQRT(ABS(PHICGI(3)))*ARK3
    ALTQ4P=ARK1*F4RID*FSI4+SIGN(1.,FSI4)*FSI4*FSI4*ARK2                DUAL1300
   1  +SIGN(1.,PHICGI(4))*F4RID*SQRT(ABS(PHICGI(4)))*ARK3
    ALTQ5=ARK1*F5ROD*FSI5+SIGN(1.,FSI5)*FSI5*FSI5*ARK2                 DUAL1310
   1  +SIGN(1.,PHICGI(3))*F5ROD*SQRT(ABS(PHICGI(3)))*ARK3
    ALTQ6=ARK1*F6ROD*FSI6+SIGN(1.,FSI6)*FSI6*FSI6*ARK2                 DUAL1320
   1  +SIGN(1.,PHICGI(4))*F6ROD*SQRT(ABS(PHICGI(4)))*ARK3
    ALTQ(3)  =  (ALTQ3P+ALTQ5)                                         DUAL1330
    ALTQ(4)  =  (ALTQ4P+ALTQ6)                                         DUAL1340
    OTM3P=F3RID*ORC1*FSI3                                              DUAL1350
   1 +(ORC2*FSI3*ABS(PHICGI(3))+ORC3*PHICGI(3))*F3RID
    OTM4P=F4RID*ORC1*FSI4                                              DUAL1360
   1 +(ORC2*FSI4*ABS(PHICGI(4))+ORC3*PHICGI(4))*F4RID
    OTM5= F5ROD*ORC1*FSI5                                              DUAL1370
   1 +(ORC2*FSI5*ABS(PHICGI(3))+ORC3*PHICGI(3))*F5ROD
    OTM6= F6ROD*ORC1*FSI6                                              DUAL1380
   1 +(ORC2*FSI6*ABS(PHICGI(4))+ORC3*PHICGI(4))*F6ROD
    OTM(3)  =  (OTM3P+OTM5)                                            DUAL1390
    OTM(4)  =  (OTM4P+OTM6)                                            DUAL1400
    RETURN                                                             DUAL1410
    END                                                                DUAL1420
```

H-2.1.11 AERODY

Presented here is the Fortran listing for the aerodynamic subprogram. Calculation of the aerodynamic forces and moments is performed in this subprogram.

```
C     SUBROUTINE AERODY
      SUBROUTINE AERODY
C**********************************************************************
C     THIS SUBPROGRAM CALCULATES THE AERODYNAMIC FORCES AND MOMENTS
C     WHICH ACT DIRECTLY ON THE SPRUNG MASS
C**********************************************************************
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI
      COMMON/AERVAR/UR,VR,WR,PBAR,QBAR,RBAR,VCW,ALPHAC,TAUC,QA,QASF,
     1              CXC,CYC,CZC,CLC,CMC,CNC,DELCXC
      COMMON/AERO/SFXS,SFYS,SFZS,SNTHES,SNPHIS,SNPSIS,APLUSB,IAERO
      COMMON/AROTBS/ TAU(40),CX(40),CY(40),CZ(40),CL(40),
     1CM(40),CN(40), ALPHA(40),DELCX(40),NAERO, NDCX,
     1 XWP(20),VYWTB(20),NWP
      EQUIVALENCE
     1                    (PARAM(142),VYW),(PARAM(143),OMXW),
     1   (PARAM(144),OMZW),(PARAM(145),RHOA),(PARAM(146),CYP),
     1   (PARAM(147),CYR),(PARAM(148),CZAL),(PARAM(149),CZQ),
     1   (PARAM(150),CLP),(PARAM(151),CLR),(PARAM(152),CMAL),
     1   (PARAM(153),CMQ),(PARAM(154),CNP),(PARAM(155),CNR),
     1   (PARAM(156),SF) ,  (PARAM(157),VL) ,  (PARAM(158),RWV)
      EQUIVALENCE (PARAM(06),A) , (PARAM(07),B) ,(PARAM(71),HCG)
      WBL=A+B
      DCG=A-WBL/2.
C    CROSS WIND DISTURBANCE
      VYW=0.0
      IF((X.LT.XWP(1)).OR.(X.GT.XWP(NWP)))GO TO 100
      VYW=XINT(X,XWP,VYWTB,NWP)
100   CONTINUE
      UR = U -VYW*SIN(PSI)
      VR = V -VYW*COS(PSI)
      WR = W
      PBAR = (P - OMXW*COS(PSI) + OMZW*THE)* APLUSB/UR
      QBAR = (Q + OMXW*SIN(PSI) - OMZW*PHI)* APLUSB/UR
      RBAR = (R - OMZW)* APLUSB/UR
      VCW =  SQRT(UR*UR + VR*VR + WR*WR)
      ALPHAC = ATAN(WR/UR)
      TAUC = ARSIN(VR/VCW)
      IF(UR.GE.0.) GO TO 110
      IF(VR) 120,121,122
  120 TAUC = TAUC -1.5708
      GO TO 110
  121 TAUC = -3.14159
      GO TO 110
  122 TAUC = TAUC + 1.5708
  110 CONTINUE
      QA     = (RHOA * VCW*VCW)/2.
      CXC = XINT(TAUC,TAU,CX,NAERC)
      CYC = XINT(TAUC,TAU,CY,NAERC)
      CZC = XINT(TAUC,TAU,CZ,NAERC)
      CLC = XINT(TAUC,TAU,CL,NAERC)
      CMC = XINT(TAUC,TAU,CM,NAERC)
```

```
      CNC = XINT(TAUC,TAU,CN,NAERC)
      DELCXC = XINT(ALPHAC,ALPHA,DELCX,NDCX)
C     AERODYNAMIC FORCES AND MOMENTS
      QASF = QA*SF
      SFXS =  (CXC + DELCXC) * QASF
      SFYS =  (CYC + CYP*PBAR + CYR*RBAR)  * QASF
      SFZS =  (CZC + CZAL*ALPHAC + CZQ*QBAR) * QASF
      SNPHIS=(VL*CLC+HCG*CYC)*QASF
      SNTHES=(VL*CMC-DCG*CZC-HCG*CXC)*QASF
      SNPSIS=(VL*CNC+DCG*CYC)*QASF
      RETURN
      END
```

H-2.1.12 STRBRK

Presented here is the Fortran listing for the steer and brake subprogram. Calculation of the steering and braking commands is performed in this subprogram.

```
C     SUBROUTINE STRBRK
      SUBROUTINE STRBRK
C***********************************************************************
C     STEERING AND BRAKING CCMMANDS CALCULATED
C***********************************************************************
      COMMON/PAUL/ D1,D2,D3,D4,SFYU,TMP,SNPHIU,SNTHEU,SNPSIU,
     1QDT,PDT, RDT ,UDT,VDT,WDT,PHIDT,THEDT,PSIDT,XDT,YDT,ZDT,
     1 AKK1,AKK2,                                  THS1,THS2,
     1AMT1,AMT2,SN,SFXU,BTVDT,ETAX,ETAL,
     1 ZIP(4),PHII(4),
     1        U1I(4),BAMI(4),MUP(4),SAMI(4),FI(4),FXUI(4),FYUI(4),GI(4),
     1        ALFI(4),BETIP(4),BETIBR(4),SLIPI(4),AM1I(4),AM2I(4),UOI(4),
     1        FCI(4),FCIMAX(4),FSI(4),
     1        ABI(4),BETAI(4),AMUI(4),SNI(4),RMI(4),GBI(4),FRIBR(4),
     1        RWZI(4),ZI(4),FRI(4),        UI(4),VI(4),WI(4),UGI(4),
     1        VGI(4),SINPSI(4),PSII(4),COSPSI(4),UGIP(4),PHICGI(4),CVI(4)
     1,ALTQ(4),OTM(4),SALTQ,FCIM,ROTM
     1,AP1,AP2,AP3,AP4,AR1,AR2,AR3,AR4,ANTI1,ANTI2,ANTI3,ANTI4
     1,DLIS(4),ZIMX(4),FBS1,FBS2,FBS3,FBS4
     1,PHIDMX
      COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI
      COMMON/THINGS/TMAX1,TMAX2,TMAX3,TQRMAX,TQFMAX,PSIMAX,ONER
      COMMON/DELS/DELSWC
      COMMON/UVW/VC,UIN
      COMMON/ZILCH/TQMAXF,TQMAXR,AKTQF,AKTQR,TQDRF,TQDRR,IDRSW
      COMMON/TIMBLK/JJTIME,TIME,DT
      COMMON/SP7BLK/N1,N2,IPCT(120),IPOTAD(120),PARAM(400)
      COMMON/NEWER/TIME25,TIME10,PSI5,PHIMAX,DSWMAX
      COMMON/STRFUN/ NST,STRTM(20),STEER(20)
      COMMON/SPINS/ARPSDT(4),PF,PFR,AVRPS(4),AVRPSD(4),
     1             ARPSD(4),ARPSDH(4),HDOT(4)
      COMMON/BRAKE/TQFBL,TQREL
      COMMON/PRESS/PRF,PLF,PRR,PLR
      COMMON/CNTROL/  EPSDSW,EPSTQR,EPDSWI,EPTQRI,ALAMDA
      COMMON/TOM/ COSABG(12) ,COABGH(12) ,COSAC(4),COSBC(4),COSAR(4),
     1COSBR(4),COSGR(4),PSIP(4),HCOSG(4),T(9)   ,XYZDOT(3)
     2 , SINPHI(4),COSPHI(4)
      DATA RAD/0.1745329E-1/
      EQUIVALENCE (PARAM(118),CS),(PARAM(123),DSW),(PARAM(121),PFL),
     1            (PARAM(117),CGAM),(PARAM(55),PTBR),(PARAM(62),ARFBR),
     1            (PARAM(122),TTD),(PARAM(124),TSW),(PARAM(115),TST),
     1            (PARAM(119),TQRBR),(PARAM(233),ALAMBD)
      EQUIVALENCE (TQFBR,PARAM(120)),(DSWCM,PARAM(114))
      EQUIVALENCE  (PARAM(108),FREQ)
C     PARAM(218) > .5, DRIVE TORQUE AND STEERING COMMANDS ARE
C     GENERATED FOR STEADY STATE WINDS
      IF(PARAM(218).GT.0.5) GO TO 8999
C        KELSEY-HAYES ANTI-LCCK SYSTEM
C        IALS = 0, DISABLE
C             = 1, ENABLE
      IALS=PARAM(23)+0.5
      DSLM=PARAM(114)/PARAM(116)
      XTMP=PARAM(121)/PARAM(192)
```

```
      IF(PARAM(126).NE.0.0)GC TO 4321                                   STRB 390
      IF(TIME.GT.TST) GO TO 6000                                        STRB 400
      DELSWC=0.0                                                        STRB 410
      GO TO 7000                                                        STRB 420
 6000 DELSWC=(TIME-TST)*DSLM                                            STRB 430
     `IF(ABS(DELSWC).GT.DSWCM)DELSWC=DSWCM*SIGN(1.0,DELSWC)             STRB 440
      IF(PARAM(128).EQ.3.0)GC TO 7000                                   STRB 450
      IF( TIME.GT.4.5 )DELSWC=DSWCM*(5.5-TIME)*SIGN(1.0,DELSWC)         STRB 460
 7000 DELSWC=DELSWC*RAD                                                 STRB 470
      PF=0.0                                                            STRB 480
      IF(TIME.LT.TTD)GO TO 4444                                         STRB 490
      PF=(TIME-CGAM)*XTMP                                               STRB 500
      IF(PARAM(128).EQ.1.0)GC TO 2223                                   STRB 510
      IF(PARAM(128).EQ.3.0)GO TO 2223                                   STRB 520
 2222 IF(PF.GT.PFL)PF=PFL                                               STRB 530
      IF(TIME.LT.CGAM)PF=0.0                                            STRB 540
      PFR=(TIME-CS)*XTMP                                                STRB 550
      IF( TIME.GT.CS )PF=PF*(CS-TIME)/10.                               STRB 560
      IF(TIME.LT.CS)PFR=0.0                                             STRB 570
      IF(PFR.GT.PFL)PFR=PFL                                             STRB 580
      IF( TIME.GT.CS )PFR=PFR*(CS-TIME)/10.                             STRB 590
C                                                                      CSTRB 600
C FUNCTION:  PF-FRONT WHEEL ERAKE TORQUE AS A FUNCTION OF FRONT        CSTRB 610
C            BRAKE LINE PRESSURE                                       CSTRB 620
C                                                                      CSTRB 630
C INPUTS:    PFR-FRONT WHEEL BRAKE LINE PRESSURE (PSI)                 CSTRB 640
C            PBF-BRAKE LINE PRESSURE(PSI), ABSISSA USED IN LINEAR      CSTRB 650
C            INTERPOLATION SUBROUTINE                                  CSTRB 660
C            TQBF-FRONT WHEEL BRAKE TORQUE (INCH-POUNDS),ORDINATE USED CSTRB 670
C            IN LINEAR INTERPOLATION SUBROUTINE                        CSTRB 680
C                                                                      CSTRB 690
C OUTPUTS:   PF-INTERPOLATED FRONT WHEEL BRAKE TORQUE AS A FUNCTION    CSTRB 700
C            OF FRONT BRAKE LINE PRESSURE                              CSTRB 710
C                                                                      CSTRB 720
C                                                                      CSTRB 740
C FUNCTION:  FR-REAR WHEEL BRAKE TORQUE AS A FUNCITON OF REAR BRAKE    CSTRB 750
C            LINE PRESSURE                                             CSTRB 760
C                                                                      CSTRB 770
C INPUTS:    PFR-BRAKE LINE PRESSURE(PSI)                              CSTRB 780
C            PBR-BRAKE LINE PRESSURE (PSI),ABSISSA                     CSTRB 790
C            TQBR-REAR WHEEL BRAKE TORQUE (INCH-POUNDS),ORDINATE       CSTRB 800
C                                                                      CSTRB 810
C OUTPUT:    FR-INTERPOLATED REAR WHEEL BRAKE TORQUE AS A FUNCTION     CSTRB 820
C            OF REAR BRAKE LINE PRESSURE                               CSTRB 830
C                                                                      CSTRB 840
      IF(IALS.EQ.1) CALL KHAIS
      TQFBR =-FF(PF)                                                    STRB 730
      TQRBR = -FR(PFR)                                                  STRB 850
      GO TO 2345                                                        STRB 860
 2223 PF=(TIME-CGAM)*XTMP                                               STRB 870
      IF(PF.GT.PFL)PF=PFL                                               STRB 880
      PFR=(TIME-CGAM)*XTMP                                              STRB 890
      IF(PFR.GT.PFL)PFR=PFL                                             STRB 900
      IF(IALS.EQ.1) CALL KHAIS
      TQFBR =-FF(PF)                                                    STRB 910
      TQRBR = -FR(PFR)                                                  STRB 920
      IF(TIME.LE.CGAM)TQFBR=C.                                          STRB 930
      IF(TIME.LE.CGAM)TQRBR=0.                                          STRB 940
      GO TO 2345                                                        STRB 950
C        DRIVE TORQUE CALCULATIONS                                      STRB 960
```

```
C        IDRSW=0, REAR WHEEL DRIVE                                       STRB 970
C             =1, FOUR WHEEL DRIVE                                       STRB 980
 4444 TQFBR= 0.0                                                         STRB 990
      TQRBR = 0.0                                                        STRB1000
      IF(IDRSW.NE.1) GO TO 5555                                          STRB1010
      TQDRF=AKTQF*(VC-U)                                                 STRB1020
      IF(TQDRF.GE.TQMAXF) TQDRF=TQMAXF                                   STRB1030
      TQFBR = 0.5*(1.-ALAMBD)*ARFBR*TQDRF                                STRB1040
 5555 TQDRR=AKTQR*(VC-U)                                                 STRB1050
      IF(TQDRR.GE.TQMAXR) TQDRR=TQMAXR                                   STRB1060
      TQRBR = 0.5*ALAMBD*TQDRR                                           STRB1070
      GO TO 2345                                                         STRB1080
 4321 CONTINUE                                                           STRB1090
      DELSWC=SIN(6.28*FREQ*TIME)*DSW*RAD                                 STRB1100
      IF(TIME.GT.0.5/FREQ)DELSWC=SIN(6.28*FREQ*TIME)*PARAM(46)*RAD
      IF(TIME.GT.1./FREQ)DELSWC=0.0                                      STRB1110
      IF((TIME.GT.0.5/FREQ).AND.(PARAM(129).GT.5.)) DELSWC = 0.0         STRB1120
      PF=0.0                                                             STRB1130
      TQRBR=0.0                                                          STRB1140
      TQFBR=0.C                                                          STRB1150
      IF(TIME.LE.TST) GO TO 8000
      DELSWC=(TIME-TST)*DSLM
      IF(ABS(DELSWC).GT.DSWCM) DELSWC=DSWCM*SIGN(1.0,DELSWC)
      DSLMD=PARAM(114)/PARAM(44)
      IF(TIME.GT.PARAM(43)) DELSWC=(TIME-PARAM(45))*DSLMD
      IF(TIME.GT.PARAM(45)) DELSWC=0.0
      DELSWC=DELSWC*RAD
 8000 CONTINUE
      IF(PARAM(125).EQ.0.0)GC TO 2345                                    STRB1160
      IF(TIME.LE.PARAM(278).OR.TIME.GT.PARAM(279))GO TO 2345             STRB1170
      PF=(TIME-PARAM(278))*26000.0                                       STRB1180
      IF(PF.GT.PFL)PF=PFL                                                STRB1190
      PFR=(TIME-PARAM(278))*26000.0
      IF(PFR.GT.PFL)PFR=PFL
      IF(IALS.EQ.1) CALL KHAIS
      TQFBR =-FF(PF)                                                     STRB1200
      TQRBR=-FR(PFR)
 2345 CONTINUE                                                           STRB1220
      IF(PARAM(193).NE.0.0)DELSWC=0.01745329*(PARAM(194)*Y    +PARAM(195) STRB1230
     1     *YDT)                                                         STRB1240
C     IF PRM(275) IS  1 STEER PROFILE DATA IS USED
      IF(PARAM(275).LE.0.) GO TO 10C
      DELSWC = XINT(TIME,STRTM,STEER,NST)
      DELSWC = DELSWC*RAD
  100 CONTINUE
      IF(IALS.EQ.0) GO TO 200
      TQFBR=-FF(PRF)*PARAM(238)
      TQFBL=-FF(PLF)*PARAM(239)
      TQRBR=-FR(PRR)*PARAM(240)
      TQRBL=-FR(PLR)*PARAM(241)
      IF(TIME.LE.CGAM)TQFBR=0.0
      IF(TIME.LE.CGAM)TQFBL=0.0
      IF(TIME.LE.CGAM)TQRBR=0.0
      IF(TIME.LE.CGAM)TQRBL=0.0
      GO TO 300
 8999 CONTINUE
      EPSDSW = XYZDOT(2)*COS(ALAMDA) - XYZDOT(1)*SIN(ALAMDA)
      EPSTQR = VC-(XYZDOT(1)*COS(ALAMDA) + XYZDOT(2)*SIN(ALAMDA))
C     VC IS INITIAL VELOCITY INPUT WITH PARAM 112 IN MPH
      EPDSWI = EPDSWI + EPSDSW*DT
```

```
      EPTQRI = EPTQRI + EPSIQR*DT
      DELSWC=-(PARAM(217)*EPDSWI + PARAM(194)*PSIDT + PARAM(195)*PSI
     2 + PARAM(193)*EPSDSW)*RAD
      TQRBR =  (PARAM(215)*EPSTQR + PARAM(216)*EPTQRI)
      TQFBR=0.
  200 CONTINUE
      TQFBR = TQFBR*PARAM(238)
      TQFBL=TQFBR*PARAM(239)
      TQRBR = TQRBR*PARAM(240)
      TQRBL=TQRBR*PARAM(241)
  300 CONTINUE
      TEMPE=ABS(DELSWC/RAD)                                             STRB1250
      IF(TEMPE.GT.DSWMAX)DSWMAX=TEMPE                                   STRB1260
      TEMPE=ABS(TQFBR)                                                  STRB1290
      IF(TEMPE.GT.TQFMAX)TQFMAX=TEMPE                                   STRB1300
      TEMPE=ABS(TQRBR)                                                  STRB1270
      IF(TEMPE.GT.TQRMAX)TQRMAX=TEMPE                                   STRB1280
      RETURN                                                            STRB1310
      END                                                               STRB1320
```

H-2.1.13 CVCALC

Presented here is the Fortran listing for the comparison variable subprogram. This subprogram collects data for comparison variable calculation.

```
C     SUBROUTINE CVCALC
      SUBROUTINE CVCALC
C*************************************************************************
C     THIS SUBROUTINE COLLECTS DATA FOR COMPARISON VARIABLE CALCULATION
C*************************************************************************
      COMMON/EXTRA/ PSI3S,PSI4S,BTV,AYSTI
      COMMON/NEWER/TIME25,TIME10,PSI5,PHIMAX,DSWMAX
      COMMON/SP7BLK/N1,N2,IPCT(120),IPOTAD(120),PARAM(400)
      COMMON/TIMBLK/JJTIME,TIME,DT
      COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI
      COMMON/COMVAR/ AXAVE,CUVRAT,BETDMX,CURTBP,TIMDEC,JUMP,DELSTR,DEL,
     1               AXI,CURVAV,ABBTV,AYMAX,RMAX,DELBET,DELPSI,BETAMX,
     1               TIMBMP,GETDL,TIMIN5,        TSTEP ,   IVHTP
      COMMON/UVW/VC,UIN
      COMMON/PAUL/ D1,D2,D3,D4,SFYU,TMP,SNPHIU,SNTHEU,SNPSIU,
     1QDT,PDT, RDT ,UDT,VDT,WDT,PHIDT,THEDT,PSIDT,XDT,YDT,ZDT,
     1 AKK1,AKK2,                                 THS1,THS2,
     1AMT1,AMT2,SN,SFXU,BTVDT,ETAX,ETAL,
     1 ZIP(4),PHII(4),
     1        U1I(4),BAMI(4),MUP(4),SAMI(4),FI(4),FXUI(4),FYUI(4),GI(4),
     1        ALFI(4),BETIP(4),BETIBR(4),SLIPI(4),AM1I(4),AM2I(4),UOI(4),
     1        FCI(4),FCIMAX(4),FSI(4),
     1        ABI(4),BETAI(4),AMUI(4),SNI(4),RMI(4),GBI(4),FRIBR(4),
     1        RWZI(4),ZI(4),FRI(4),        UI(4),VI(4),WI(4),UGI(4),
     1        VGI(4),SINPSI(4),PSII(4),COSPSI(4),UGIP(4),PHICGI(4),CVI(4)
     1,ALTQ(4),OTM(4),SALTQ,FCTM,ROTM
     1,AP1,AP2,AP3,AP4,AR1,AR2,AR3,AR4,ANTI1,ANTI2,ANTI3,ANTI4
     1,DLIS(4),ZIMX(4),FBS1,FBS2,FBS3,FBS4
     1,PHIDMX
      COMMON/THINGS/TMAX1,TMAX2,TMAX3,TQRMAX,TQFMAX,PSIMAX,ONER
      REAL*4 MPHIPS
      DATA MPHIPS/17.6/
      DATA RAD/0.1745329E-1/
      EQUIVALENCE (PARAM(123),DSW),(PARAM(115),TST),(PARAM(117),CGAM)
      EQUIVALENCE (PARAM(108),FREQ)
C     LONGITUDINAL AND LATERAL ACCELERATION CALCULATION
      ETAX = (UDT-V*R+W*Q)/386.4
      ETAL = (VDT+R*U-W*P)/386.4
      BTV = ATAN(V/U)
      BTVDT = (U*VDT-V*UDT)/(U*U)
      ONER = (R+BTVDT)/SQRT(U**2+V**2)
C     COMPARISON VARIABLE DATA COLLECTION
      IF(IVHTP.GT.2) GO TO 402
C     COMPARISON VARIABLES FOR VHTP # 1
C     AXAVE = AVERAGE LONGITUDINAL DECELERATION
      IF(U.GT.(UIN-88.)) GO TO 400
      AXI = AXI + ETAX
      GO TO 401
  400 TIMIN5 = TIME
  401 CONTINUE
      TIMDEC  = TIME - TIMIN5
  402 CONTINUE
      IF(IVHTP.NE.2) GO TO 412
```

```
C       VHTP #2 COMPARISON VARIABLES                                    CVCA 540
C       AVERAGE PATH CURVATURE RATIO , CUVRAT                           CVCA 550
C       AVERAGE LONGITUDINAL DECELERATION, AXAVE                        CVCA 560
C       PEAK BODY SIDESLIP RATE, BETDMX                                 CVCA 570
        IF (TIME.LT.CGAM) GO TO 410                                     CVCA 580
        IF( TIME.GT. (CGAM + 1.)) GO TO 411                             CVCA 590
        CURVAV = CURVAV + ONER                                          CVCA 600
        ABBTV = ABS(BTV)                                                CVCA 610
        ABTVDT = ABS(BTVDT)                                             CVCA 620
        IF(ABBTV.GT.BETAMX) BETAMX = ABBTV                              CVCA 630
        IF(ABTVDT.GT.BETDMX) BETDMX = ABTVDT                            CVCA 640
        GO TO 411                                                       CVCA 650
  410   CURTBP = ONER                                                   CVCA 660
  411   CONTINUE                                                        CVCA 670
   412 CONTINUE                                                         CVCA 680
        IF(IVHTP.NE.3) GO TO 422                                        CVCA 690
C       VHTP #3                                                         CVCA 700
        IF((GETDL.EQ.0.).AND.(JUMP.EQ.0)) GO TO 420                     CVCA 710
        IF(TIME.GT.(TIMBMP + 1))  GO TO 421                             CVCA 720
        JUMP =1                                                         CVCA 730
        CURVAV = CURVAV + ONER                                          CVCA 740
        ABTVDT = ABS(BTVDT)                                             CVCA 750
        ABBTV  = ABS(BTV)                                               CVCA 760
        IF(ABTVDT.GT.BETDMX) BETDMX = ABTVDT                            CVCA 770
        IF(ABBTV.GT.BETAMX) BETAMX = ABBTV                              CVCA 780
        GO TO 421                                                       CVCA 790
   420 CURTBP = ONER                                                    CVCA 800
        TIMBMP =  TIME                                                  CVCA 810
   421 CONTINUE                                                         CVCA 820
   422 CONTINUE                                                         CVCA 830
        IF(IVHTP.NE.4) GO TO 432                                        CVCA 840
C       VHTP #4  COMPARISON VARIABLES                                   CVCA 850
        IF(TIME.LT.TST) GO TO 430                                       CVCA 860
        IF(TIME.GT.(TST + 2.)) GO TO 431                                CVCA 870
        CURVAV = CURVAV + ONER                                          CVCA 880
        ABTVDT = ABS(BTVDT)                                             CVCA 890
        ABBTV  = ABS(BTV)                                               CVCA 900
        IF(ABTVDT.GT.BETDMX) BETDMX = ABTVDT                            CVCA 910
        IF(ABBTV.GT.BETAMX) BETAMX = ABBTV                              CVCA 920
        DELBET = BETAMX - BETA                                          CVCA 930
        GO TO 431                                                       CVCA 940
  430   BETA = BTV                                                      CVCA 950
  431   CONTINUE                                                        CVCA 960
   432 CONTINUE                                                         CVCA 970
        IF(IVHTP.NE.5) GO TO 442                                        CVCA 980
C       VHTP #5  COMPARISON VARIABLES                                   CVCA 990
        IF(TIME.GT.((1./FREQ) + 1.4)) GO TO 450                         CVCA1000
        IF(DSW.GT.0) GO TO 460                                          CVCA1010
        DELSTR= DELSTR + ABS(Y + 144.)                                  CVCA1020
        GO TO 461                                                       CVCA1030
   460 CONTINUE                                                         CVCA1040
        DELSTR=DELSTR + ABS(Y - 144.)                                   CVCA1050
   461 CONTINUE                                                         CVCA1060
        ABBTV = ABS(BTV)                                                CVCA1070
        IF(ABBTV.GT.BETAMX) BETAMX = ABBTV                              CVCA1080
        DELPSI = PSI                                                    CVCA1090
   450 CONTINUE                                                         CVCA1100
   442 CONTINUE                                                         CVCA1110
C       VHTP #6 COMPARISON VARIABLE                                     CVCA1120
        IF(ABS(PHIDT).GT.PHIDMX) PHIDMX = ABS(PHIDT)                    CVCA1130
        IF(ABS(ETAL).GT.AYMAX) AYMAX= ABS(ETAL)                         CVCA1140
```

```
      TEMPE = ABS(R/RAD)
      IF(TEMPE.GT.RMAX) RMAX=TEMPE
      TEMPE = ABS(PSI)
      IF(TEMPE.GT.PSIMAX) PSIMAX=TEMPE
      TEMPE = ABS(PHI/RAD)
      IF(TEMPE.GT.PHIMAX) PHIMAX=TEMPE
      IF(U    .GE.10.0*MPHIPS)TIME10=TIME
      IF(U    .GE.25.0*MPHIPS)TIME25=TIME
      IF(TIME.LE.5.0)PSI5=PSI    /RAD
      RETURN
      END
```

H-2.1.14 RTMON

Presented here is the Fortran listing for the real-time mode initialization subprogram. The following is performed in RTMON:

1. Initialization of order programs to perform real-time input/output.

2. Initiation of simulation runs.

3. Suspension of the simulation's OS processing until the real-time processing is completed.

```
C     SUBROUTINE RTMON
      SUBROUTINE RTMON
C*********************************************************************
C     THIS SUBPROGRAM PERFORMS THE FOLLOWING:
C        1) INITIALIZATION OF ORDER PROGRAMS TO PERFORM REAL-TIME
C           INPUT/OUTPUT
C        2) INITIATION OF SIMULATION RUNS
C        3) SUSPENSION OF THE SIMULATION'S OS PROCESSING UNTIL THE
C           REAL-TIME PROCESSING IS COMPLETED
C*********************************************************************
      COMMON/OSMON/ IREALT,NNNN
      COMMON/EVTRB/SAVE0,SAVE1,SAVE2
      COMMON/OSTRAN/ ICT,IRT,MOPU,IRUNS,LRUNS,REALT,ITRUNS
      COMMON/APL/ OPEN  ,RTSW  ,LDTSW ,RBSW
      COMMON/RBBLK/ AD1RB,ICRB,OPRB,PILRB
      COMMON /RBBLK/ TCNBUF,TIMBUF,LDARB ,TDARB ,PILRB1
      COMMON/RBBLK/SLRB05,RLRB05
      COMMON /ECBBLK/PILECB,TCNECB,TIMECB,ADAECB,TDAECB
      COMMON/ECBBLK/ AD1ECB,ICECB,OPECB
      COMMON /ECBBLK/OSECB ,DONECB,SLECB5,RLECB5
      COMMON/INOUT/ IN(48),DACO(48),ISW1,ISW7,IPRT
C
      REAL*8                   PILRB(3)    ,LDARB(23)   ,TCNBUF(8)
      REAL*8       TIMBUF(8)
      REAL*8       SAVE2(16)   ,PILRB1(3)                ,AD1RB(12)
      REAL*8                   OPRB(6)     ,TDARB(6)
      REAL*8       SAVE0(16)   ,SAVE1(16)                ,ICRB(6)
      REAL*8   SLRB05(6),RLRB05(6)
C
      REAL*4               IN
      REAL*4       ADC2(24)    ,ADC1(24)
C
      INTEGER*4                TCNECB      ,TIMECB
      INTEGER*4    CONSL/01/   ,PILECB     ,ADAECB      ,TDAECB
      INTEGER*4                             IMODOP/04/  ,OPECB
      INTEGER*4 FIRST/0/,LAST/47/
      INTEGER*4 NONE/0/,AD1ECB, IMODIC/06/,ICECB
      INTEGER*4      MONE/-1/   ,F1/00/     ,L1/47/
      INTEGER*4    TDAECB
      INTEGER*4    OSECB       ,DONECB
      INTEGER*4   SCL05/5/,RCL05/5/,SLECB5,RLECB5
C
```

```
      INTEGER*2                NUMEVT/03/ ,ZERO/00/                     RTMO 340
      INTEGER*2   UNIT/19/                                              RTMO 350
      INTEGER*2 TWO/02/                                                 RTMO 360
      INTEGER*2   RTSW   ,RBSW   ,LDTSW ,OPEN   ,OPDN                   RTMO 370
C                                                                       RTMO 380
      EQUIVALENCE (ADC1(24),IN(24))      ,(ADC2(1),IN(25))              RTMO 390
C                                                                       RTMO 400
      EXTERNAL         INIT,CART ,ENDRUN,HYBINT                         RTMO 410
C                                                                       RTMO 420
      IF( RBSW.EQ.1 ) GO TO 200                                         RTMO 430
         CALL BLJCB( 'J007',CSECB,NUMEVT,NONE )                         RTMO 440
         CALL DEFEP( INIT,SAVE0,ZERO,'NONE','NO' )                      RTMO 450
         CALL DEFEP( ENDRUN,SAVE1,ZERO,'NONE','NO' )                    RTMO 460
         CALL DEFEP( CART,SAVE2,ZERO,'NONE','NO' )                      RTMO 470
         CALL CRBCRB( F1,L1,ADC1,AD1RB,AD1ECB,CONSL )                   RTMO 480
         CALL TLDARB( TDARB,TDAECB,CONSL )                              RTMO 490
         CALL SSCLRB(SCL05,SLRB05,SLECB5,CONSL)                         RTMO 500
         CALL RSCLRB(RCL05,RLRB05,RLECB5,CONSL)                         RTMO 510
         CALL SAMORB( IMODIC,ICRB,ICECB,CONSL )                         RTMO 520
         CALL SAMORB( IMODOP,OPRB,OPECB,CONSL )                         RTMO 530
         RBSW   = 1                                                     RTMO 550
  200 CONTINUE                                                          RTMO 560
      IF(IREALT.EQ.0 ) GO TO 210                                        RTMO 570
      IF(NNNN.EQ.1) GO TO 320                                           RTMO 700
      NNNN = 1                                                          RTMO 710
         CALL RTOPN                                                     RTMO 600
         CALL RTACT( ZERO,'J007' )                                      RTMO 610
  320 CONTINUE                                                          RTMO 740
         CALL DEFPR( UNIT,HYBINT,'J007' )                               RTMO 630
         LDTSW  = 0                                                     RTMO 640
         OSECB  = 0                                                     RTMO 650
         CALL RTACT( TWO ,'J007' )                                      RTMO 660
         CALL WAITRT( OSECB )                                           RTMO 670
         CALL WAITBU( 200 )                                             RTMO 680
         CALL DEFPR( UNIT,NONE,'J007' )                                 RTMO 690
      GO TO 215                                                         RTMO 700
  210 CONTINUE                                                          RTMO 710
         CALL LBDAFP( FIRST,LAST,DACO,IERR )                            RTMO 720
         CALL TLDA                                                      RTMO 730
         CALL CRBCFP( F1,L1,ADC1,ICRBCB )                               RTMO 740
      CALL MODEL                                                        RTMO 750
  215 CONTINUE                                                          RTMO 760
      RETURN                                                            OVERLAY
      ENTRY RTMONT                                                      OVERLAY
      IF(IREALT.EQ.0) GO TO 310                                         RTMO 960
      OSECB = 0                                                         OVERLAY
      CALL HPOST(DONECB,'DN')                                           OVERLAY
      CALL WAITRT(OSECB)                                                OVERLAY
  310 CONTINUE
      RETURN                                                            RTMO 770
      END                                                               RTMO 780
```

H-2.1.15 RTIME

Presented here is the Fortran listing of the real-time executive subprogram. The following is performed in RTIME:

1. Assignment of priority interrupt addresses to real-time events.

2. Initialization of the interval timer for computation cycle timing.

3. Execution of all real-time input/output.

4. Checks for end-of-run conditions.

5. Deactivation of real-time mode at the end of a simulation run.

```
C     SUBROUTINE RTIME
      SUBROUTINE RTIME
C***********************************************************************
C     THIS SUBPROGRAM PERFORMS THE FOLLOWING:
C        1) ASSIGNMENT OF PRIORITY INTERRUPT ADDRESSES TO
C           REAL-TIME EVENTS
C        2) INITIATION OF THE INTERVAL TIMER FOR COMPUTATION CYCLE
C           TIMING
C        3) EXECUTION OF ALL REAL-TIME INPUT/OUTPUT
C        4) CHECKS FOR END-OF RUN CONDITIONS
C        5) DEACTIVATION OF REAL-TIME MODE AT THE END OF A
C           SIMULATION RUN
C***********************************************************************
      COMMON/APL/ OPEN  ,RTSW  ,LDTSW ,RBSW
      COMMON/RBBLK/ AD1RB,ICRB,OPRB,PILRB
      COMMON /RBBLK/ TCNBUF,TIMBUF,LDARB ,TDARB ,PILRB1
      COMMON/RBBLK/SLRB05,RLRB05
      COMMON /ECBBLK/PILECB,TCNECB,TIMECB,ADAECB,TDAECB
      COMMON/ECBBLK/ AD1ECB,ICECB,OPECB
      COMMON /ECBBLK/OSECB ,DONECB,SLECB5,RLECB5
      COMMON/INOUT/ IN(48),DACO(48),ISW1,ISW7,IPRT
      COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI
      COMMON/TIMBLK/JJTIME,TIME,DT
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      COMMON/NEWER/TIME25,TIME10,PSI5,PHIMAX,DSWMAX
      COMMON/NONAME/XEND,O,EXIT2
      COMMON/NODLY/INDXCN
      DIMENSION CSI(4),XBM(4),SLP(4)
      REAL*8      BUFF(8)    ,PILRB(3)   ,LDARB(23)  ,TCNBUF(8)
      REAL*8      TIMBUF(8)
      REAL*8 ICRB(6),PILRB1(3), AD1RB(12)
      REAL*8                  OPRB(6)    ,TDARB(6)
      REAL*8     BUFF1(8)
      REAL*8   SLRB05(6),RLRB05(6)
C
      REAL*4             IN
      REAL*4      ADC2(24)   ,ADC1(24)
C
```

```
      INTEGER*4   TIMCAN     ,TCNECB     ,TIMECB
      INTEGER*4   CONSL/01/  ,PILECB     ,ADAECB     ,TDAECB
      INTEGER*4              EVTRET/02/ ,TIMINT/120000/
      INTEGER*4 SLECB5,RLECB5 ,         FIRST/00/  ,LAST/47/
      INTEGER*4 OPECB,AD1ECB,ICECB
      INTEGER*4   TDAECB     ,STATUS
      INTEGER*4   OSECB      ,DONECB
      INTEGER*4  PILCB1
C
      INTEGER*2   PILIST(2)/1,0/,EVTLST/1/
      INTEGER*2   TWO  /02/ ,ONE/01/
      INTEGER*2   RTSW  ,RBSW  ,LDTSW ,OPEN
C
      EQUIVALENCE (ADC1(24),IN(24))      ,(ADC2(1),IN(25))
      EQUIVALENCE (PARAM(016),ROOVER)
C
C     EVENT 0
C
      ENTRY INIT
         CALL PGET( PILIST, C  ,'J007',PILRB1 )
         PILECB = 0
         CALL PCAN( PILIST,BUFF,PILECB )
         CALL HIOCHK( PILECB )
         CALL PEVT( PILIST,EVTLST,'J007',PILRB )
         DONECB = 0
         CALL HWAIT( DONECB )
         CALL PREL( PILIST,'J007',PILRB1 )
         CALL HDONE( 'DN' )
      CALL HEXIT
C
C     EVENT 1
C
      ENTRY ENDRUN
      TCNECB = 0
         CALL RDTIMR( TIMCAN,TCNECB,'CANC',TCNBUF )
         CALL HIOCHK( TCNECB )
         PILECB = 0
         CALL PDAC( PILIST,BUFF,PILECB )
         CALL HIOCHK( PILECB )
         PILECB = 0
         CALL PCAN( PILIST,BUFF,PILECB )
         CALL HIOCHK( PILECB )
      ICECB  = 0
         CALL HIOREQ( ICRB )
         CALL HIOCHK( ICECB )
         CALL RTCAN( TWO  ,STATUS )
         CALL HOSPST( 'FN' )
      CALL HEXIT
C
C     EVENT 2
C
      ENTRY CART
      IF( LDTSW.EQ.1 ) GO TO 230
      PILCB1 = 0
      CALL PCAN(PILIST,BUFF1,PILCB1)
      CALL HIOCHK(PILCB1)
      PILCB1 = 0
         CALL PACT( PILIST,BUFF1,PILCB1 )
         CALL HIOCHK  ( PILCB1 )
      OPECB  = 0
      TIMECB = 0
```

```
         CALL HIOREQ( OPRB )                                            RTIM 890
      TIMINT = 1.E06*DT/PARAM(175)                                      RTIM 860
         CALL LDTIMR( TIMINT,TIMECB,EVTRET,TIMBUF )                     RTIM 870
         LDTSW  = 1                                                     RTIM 900
      GO TO 250
  230 CONTINUE                                                          RTIM 910
      SLECB5=0                                                          RTIM 920
      TDAECB = 0                                                        RTIM 930
      AD1ECB = 0                                                        RTIM 940
         CALL HIOREQ(SLRB05)                                            RTIM 950
         CALL HIOREQ( AD1RB )                                           RTIM 970
      J=0                                                               RTIM 980
      DO 200 I=1,INDXCN                                                 RTIM 990
      J=J+1                                                             RTIM1000
200   CONTINUE                                                          RTIM1010
C
         CALL HIOCHK( AD1ECB )                                          RTIM1020
      CALL MODEL                                                        RTIM1030
      ADAECB = 0                                                        RTIM1040
      RLECB5=0                                                          RTIM1050
         CALL LBDART( FIRST,LAST,DACC,LDARB ,ADAECB,CONSL )             RTIM1060
         CALL HIOREQ( TDARB )                                           RTIM 960
         CALL HIOREQ(RLRB05)                                            RTIM1070
C     APL WILL TERMINATE REAL-TIME RUN IF EITHER                        RTIM1080
C     CONDITION SHOWN BELOW IS SATISFIED                                RTIM1090
      O=SQRT(U*U+V*V)                                                   RTIM1100
      IF(U.LE.0.1)CALL RTACT(ONE,'J007')                                RTIM1110
      IF(PHIMAX.GT.ROOVER) CALL RTACT(ONE,'J007')
      IF(( ISW1.EQ.1 ).OR.( ISW7.EQ.1 )) CALL RTACT( ONE   ,'J007' )    RTIM1130
      IF( TIME.LE.XEND.AND.O.GE.EXIT2 ) GO TO 250                       RTIM1140
      CALL RTACT( ONE,'J007' )                                          RTIM1150
  250 CONTINUE                                                          RTIM1160
      CALL HEXIT                                                        RTIM1170
      RETURN                                                            RTIM1180
      END                                                               RTIM1190
```

H-2.1.16 CMPVAR

Presented here is the Fortran listing for the performance comparison variable (PCV) calculation subprogram. The calculation and output of the PCV's are performed in CMPVAR following each simulation run.

```
C     SUBROUTINE CMPVAR
      SUBROUTINE CMPVAR
C*********************************************************************
C     THE CALCULATION AND OUTPUT OF THE CV'S ARE PERFORMED IN THIS
C     SUBPROGRAM FOLLOWING EACH SIMULATION RUN
C*********************************************************************
      COMMON/COMVAR/ AXAVE,CUVRAT,BETDMX,CURTBP,TIMDEC,JUMP,DELSTR,DEL,
     1               AXI,CURVAV,ABBTV,AYMAX,RMAX,DELBET,DELPSI,BETAMX,
     1               TIMBMP,GETDL,TIMIN5,     TSTEP,       IVHTP
      COMMON/THINGS/TMAX1,TMAX2,TMAX3,TQRMAX,TQFMAX,PSIMAX,ONER
      COMMON/NEWER/TIME25,TIME10,PSI5,PHIMAX,DSWMAX
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      COMMON/SAYERS/SD,TSTOP
      COMMON/NONAME/XEND,O,EXIT2
      COMMON/EFFS/ANUM,ADEN,ANUMDT,ADENDT,ANUMO,ADENO,ANUMDO,ADENDO,
     1   ANOUT,ADOUT
      COMMON/COMBLK/ SM,CIP,CIVP,RZF,RZR,A2T,CA20,CA23,TSFO2,
     1     TRO2,TFO2,TSO2,G,THRD,TWN7,R2T,RA20,RA23
      COMMON/TIMBLK/JJTIME,TIME,DT
      EQUIVALENCE(PARAM(108),FREQ)
      DATA CURV1G/.00078/
      DATA LPTR/2/
C     CALCULATION OF COMPARISON VARIABLES
      IF(TIMDEC.EQ.0.) TIMDEC=.00000001
      IF(CURTBP.EQ.0. ) CURTBP=.00000001
      GO TO(1,2,3,4,5,6), IVHTP
      AXAVE = AXI*DT/TIMDEC
      GO TO 10
    1 CONTINUE
      AXAVE = AXI*DT/TIMDEC
      AXABS=ABS(AXAVE)
      IF(TIME.LT.PARAM(117)) GO TO 10
      TSTOP=EXIT2/(AXABS*G)
      SD=(AXAVE*G*TSTOP**2)/2. + EXIT2*TSTOP + ANUM
      GO TO 10
    2 CONTINUE
      AXAVE = AXI*DT/TIMDEC
      AXABS=ABS(AXAVE)
      TSTOP=EXIT2/(AXABS*G)
      SD=(AXAVE*G*TSTOP**2)/2. + EXIT2*TSTOP + ANUM
      CUVRAT =  CURVAV * DT/CURTBP
      GO TO 10
    3 CONTINUE
      CUVRAT = CURVAV * DT/CURTBP
      GO TO 10
    4 CONTINUE
      CUVRAT = CURVAV*.5*DT/CURV1G
      GO TO 10
    5 CONTINUE
      DEL = (DELSTR*DT/((1./FREQ)+1.4))/12.
    6 CONTINUE
```

```
 10 CONTINUE                                                          CMPV 330
    RMAX = RMAX/57.3                                                  CMPV 340
    WRITE(LPTR,2345) AXAVE,TIMDEC,CUVRAT,BETDMX,BETAMX,DELBET,        CMPV 350
   1AYMAX,PHIMAX,RMAX,DEL,DELPSI,DSWMAX,TQFMAX,TQRMAX                 CMPV 360
2345 FORMAT('0 AXAV=',F8.3,' DECL TIME=',F8.3,' AVCUR=',F8.3,' BTDMAX='CMPV 370
   1,F8.3,' BTMAX=',F8.3,' DELBT=',F8.3/                              CMPV 380
   1'0AYMAX=',F8.3,' PHIMAX=',F8.3,' RMAX=',F8.3,' LANE CHNG DEL=',   CMPV 390
   1F8.3,' DELPSI=',F8.3,' MAX STEER=',F8.3/                          CMPV 400
   1'0FTRQMAX=',F9.1,' RTRQMAX=',F9.1/)                               CMPV 410
    RETURN                                                            CMPV 420
    END                                                               CMPV 430
```

H-2.1.17 QSTD

Presented here is the Fortran listing of the subprogram which outputs nonstandard data. The performance comparison variables are output from QSTD.

```
C     SUBROUTINE QSTD
      SUBROUTINE QSTD
C***********************************************************************
C     STANDARD END OF RUN DATA IS OUTPUT FROM THIS SUBPROGRAM
C***********************************************************************
      COMMON/DEVICE/KEYBD,ITTY,ICDRD,LPTR,LPNT
      COMMON/COMVAR/ AXAVE,CUVRAT,BETDMX,CURTBP,TIMDEC,JUMP,DELSTR,DEL,
     1                 AXI,CURVAV,ABBTV,AYMAX,RMAX,DELBET,DELPSI,BETAMX,
     1                 TIMBMP,GETDL,TIMIN5,       TSTEP ,    IVHTP
      COMMON/THINGS/TMAX1,TMAX2,TMAX3,TQRMAX,TQFMAX,PSIMAX,ONER
      COMMON/NEWER/TIME25,TIME10,PSI5,PHIMAX,DSWMAX
      WRITE(ITTY,2345) AXAVE,TIMDEC,CUVRAT,BETDMX,BETAMX,DELBET,
     1AYMAX,PHIMAX,RMAX,DEL,DELPSI,DSWMAX,TQFMAX,TQRMAX
 2345 FORMAT('0 AXAV=',F8.3,' DECL TIME=',F8.3,' AVCUR=',F8.3,' BTDMAX='
     1,F8.3,' BTMAX=',F8.3,' DELBT=',F8.3/
     1' AYMAX=',F8.3,' PHIMAX=',F8.3,' RMAX=',F8.3,' LANE CHNG DEL=',
     1F8.3,' DELPSI=',F8.3,' MAX STEER=',F8.3/
     1' FTRQMAX=',F10.0,' RTRQMAX=',F10.0/)
      RETURN
      END
```

H-2.1.18 ERMONT

Presented here is the Fortran listing for the abnormal simulation operation subprogram. The conditions of vehicle roll-over, DAC overrange, and ADC overrange are detected by ERMONT when single-run execution is performed.

```
C     SUBROUTINE ERMONT(MOPU,ORNAME,PHIMAX)
      SUBROUTINE ERMONT(MOPU,CRNAME,PHIMAX)
C*************************************************************************
C     THE CONDITIONS OF VEHICLE RCLL-OVER, DIGITAL-TO-ANALOG CONVERTER
C     OVERRANGE, AND ANALOG-TO-DIGITAL OVERRANGE  ARE DETECTED BY
C     THIS SUBPROGRAM WHEN SINGLE RUN EXECUTION IS PERFORMED
C*************************************************************************
      COMMON/EMON/IERDAC(10),TERDAC(10),IDACK,IENDR(20)
      COMMON/ERMON2/ IERADC(10),TERADC(10),IADCK
      COMMON/DACADC/ NAMDAC,NAMADC,IDAC,IADC,ADCNUM,DACNUM
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      EQUIVALENCE (PARAM(016),ROOVER)
      INTEGER*2 NAMDAC(48),NAMADC(48),IDAC(48),IADC(48),ADCNUM,DACNUM
      REAL*8 ORNAME(400)
      IF(PHIMAX.LT.ROOVER) GC TO 200
      WRITE(MOPU,205) PHIMAX
  205 FORMAT(' VEHICLE ROLL CVER PHIMAX=',F8.2)
  200 CONTINUE
      IF(IDACK.LT.1) GO TO 100
      WRITE(MOPU,105)
      WRITE(MOPU,106)
      WRITE(MOPU,107)  (TERDAC(J),CRNAME(NAMDAC(IERDAC(J))),
     1 IDAC(IERDAC(J)),J=1,IDACK)
  105 FORMAT(' DAC OVERLOAD')
  106 FORMAT('   TIME        VAR')
  107 FORMAT(F8.2,2X,A6,' (',I4,')')
  100 CONTINUE
      IF(IADCK.LT.1) GO TO 3C0
      WRITE(MOPU,305)
      WRITE(MOPU,106)
      WRITE(MOPU,107)  (TERADC(J),CRNAME(NAMADC(IERADC(J))),
     1 IADC(IERADC(J)),J=1,IADCK)
  305 FORMAT(' ADC OVER RANGE')
  300 CONTINUE
      RETURN
      END
```

H-2.1.19 NTRACT

Presented here is the Fortran listing for the NTRACT subprogram. This subprogram is for simulation control via the interactive routines using the option command.

```
C     SUBROUTINE NTRACT(*,*,*,*)
      SUBROUTINE NTRACT(*,*,*,*)
C***********************************************************************
C     THIS SUBPROGRAM IS FOR SIMULATION CONTROL VIA THE INTERACTIVE
C     ROUTINES USING THE OPTION COMMAND
C***********************************************************************
C
C**************************** COMMON AREAS ****************************
C
      COMMON/START/ ZDUMMY(4)
      COMMON/TABBS/ ITABP,ITABI,ITNAM,TABNUM
      COMMON/EMON/IERDAC(10),TERDAC(10),IDACK,IENDR(20)
      COMMON/ERMON2/ IERADC(10),TERADC(10),IADCK
      COMMON/NEWER/TIME25,TIME10,PSI5,PHIMAX,DSWMAX
      COMMON/DEVICE/KEYBD,ITTY,ICDRD,LPTR,LPNT
      COMMON /ECBBLK/PILECB,ICNECB,TIMECB,ADAECB,TDAECB
      COMMON/ECBBLK/ AD1ECB,ICECB,OPECB
      COMMON /ECBBLK/OSECB ,DONECB,SLECB5,RLECB5
      COMMON/OSMON/ IREALT,NNNN
      COMMON/OSTRAN/ ICT,IRT,MOPU,IRUNS,LRUNS,REALT,ITRUNS
      COMMON/DACADC/ NAMDAC,NAMADC,IDAC,IADC,ADCNUM,DACNUM
      COMMON/IO/ DACPLA,ADCPLA,SCALDC,SCALAC
      COMMON/TRACK/JIN,IKEEP,ATRACK,ISAMP,ONTIM,OFFTIM,ITRA,
     1 ITRAA,ITRNA,ITRIA
      COMMON/UNREAD/NAMEA,IWRDCT,INUMCT,LSTART,INDEXA,
     1 FNUMA,LAST,ILOP
      COMMON/FIND/ORNAME(400),NCOM,RSVAL(002),IORDER(400)
      COMMON/TIMBLK/JJTIME,TIME,DT
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      COMMON/OVRLAY/ OPTEST,VALMR,FINLMR,NTIME1,NTIME2,LOCAT,LOOPN
      COMMON/NTCOM/ OUTNAM,UNNAM,MODENA,JDATE                          OVERLAY
      COMMON/NTCOM/ IOU,MODE,DEVICE,IMODE                              OVERLAY
      COMMON/PLOTA/IPLF,NP
C
C***********************************************************************
C
      REAL*8 NAMEA(10),RETURN
      REAL*8 OPTION(20),OPTEST     ,ASELT(15),REMOVE,RESET
      REAL*8 BLANK
      REAL*8 NMES,NTESTP,NTESTO
      REAL*8 NADCL,NDACL,NDUMP,NNPC,NPLOT,NSTD
      REAL*8 NTRACK,NTM,NTIME,NTABLE
      REAL*8 OUTNAM(21),NX      ,NTERM,NRESR,NIC,NADCA
      REAL*8 NXM,UNNAM(3),MODENA(4)
      REAL*8 ORNAME
      REAL*8 NSAMPL,NLA
      REAL*8 NDACA,NMULT,CNAME,NII,NFF
      REAL*8 NUOPT,NUOT1,NSTAT
      REAL*8 ENDDAC,ENDADC
      REAL*4 ZDUMMY
      REAL*4 VALMR(20),FINLMR(20)
      REAL*4 FNUMA(10)
      REAL*4                 SCALAC(48),SCALDC(48)
```

```
      REAL*4 IPOT,IPOTAD
      REAL*4 XDOWN(100),YACRCS(100)
      INTEGER*4 RTSW,            INDEXA(10)
      INTEGER*4 ITABI(9)
      INTEGER*4 DONECB,OSECB,TIMINT
      INTEGER*4 ITABP(9),TABNUM,ITNAM(9)
      INTEGER*2 ITRAA(50),ITRNA(50),ITRIA(50)
        INTEGER*2 LOCAT(20),LOOPN(20)
      INTEGER*2 DEVICE(21),ICRDER,IMODE(20)
      INTEGER*2 DACNUM,ADCNUM,DACPLA(48),ADCPLA(48)
      INTEGER*2 NAMDAC(48),NAMADC(48),IDAC(48),IADC(48)
      DIMENSION  JDATE(3)
      DIMENSION ATRACK(2000)
      DIMENSION BVALUE(2)
      DIMENSION IVALUE(2)
      EQUIVALENCE  (BVALUE(1),ZDUMMY(1))
      EQUIVALENCE  (BVALUE(1),IVALUE(1))
      EQUIVALENCE  (OPTION(1),NX)   ,(OPTION(2),NIC)   ,(OPTION(3),NTERM),
     1     (OPTION( 4),NADCA) ,(OPTION( 5),NDACA) ,(OPTION( 6),NFF)    ,
     2     (OPTION( 7),NII)   ,(OPTION( 8),NMES)  ,(OPTION( 9),NTESTP),
     3     (OPTION(10),NRESR) ,(OPTION(11),RESET) ,(OPTION(12),REMOVE),
     4     (OPTION(13),NMULT) ,(OPTION(14),NXM)   ,(OPTION(15),NUOPT)
      EQUIVALENCE (ASELT( 1),NTIMD),(ASELT( 2),NDUMP),(ASELT( 3),NSTD),
     1     (ASELT( 4),NTESTO)  ,(ASELT( 5),NLA)    ,(ASELT( 6),NTRACK) ,
     2     (ASELT( 7),NTABLE)  ,(ASELT( 8),NPLOT)  ,(ASELT( 9),NDACL)  ,
     3     (ASELT(10),NADCL)   ,(ASELT(11),NSAMPL) ,(ASELT(12),NNPC)   ,
     4     (ASELT(13),NTM)     ,(ASELT(14),NSTAT)  ,(ASELT(15),NUOT1)
C
C *********************************************************************
C
      DATA BLANK/' '/
C     DATA OUTNAM/'STD','TM','TABLE',18*' '/                            OVERLAY
C     DATA DEVICE/2,2,3,17*0/                                           OVERLAY
C     DATA IMODE/1,1,3,17*0/                                            OVERLAY
C     DATA UNNAM/'L.......','T.......','B.......'/                      OVERLAY
C     DATA MODENA/'S.......','XEQ.....','M.......','A.......'/          OVERLAY
C
      DATA OPTION/'X','IC', 'TERM','ADCA','DACA','F','I','MES',
     1            'TEST','RE-STR','RESET','REMOVE','MULTI','XM',
     2            'UOPT',5*'ZZZZZZZZ'/
      DATA RETURN/'        '/
      DATA ASELT/'T+D','DUMP','STD','TESTO','LA','TRACK','TABLE','PLOT',
     1            'DACL','ADCL','SAMPLE','PC','TM','STAT' ,'UOUT1'/
C       1 LOAD JDATE ARRAY
C       2 WRITE  TIME AND DATE
      CALL  IDATE(JDATE)
      CALL TIMDAT(JDATE,ITTY)
C
C*********************************************************************
C
C ***************
C *             *
C * OPTION TEST * - ENTER A NAME FROM KEYBD (OPTEST)
C *             *
C **************
C
C         1 IF OPTEST IS AN OPTION KEYWORD PASS CONTROL TO OPTION EXECUTI
C         2 IF OPTEST IS AN OUTPUT KEYWORD PASS CONTROL TO OUTPUT ARRAY A
C         3 IF OPTEST IS IN THE ANAME ARRAY WRITE ITS PRESENT AND INITIAL
C         4 IF OPTEST IS EQUAI TO RESET  GO TO RESET ROUTINE
C         5 IF NONE OF THE ABCVE ENVCKE ERROR MONITOR
```

```
C                                                                       NTRA1060
 8749 WRITE(ITTY,8754)                                                  NTRA1070
 8754 FORMAT(1H0,'OPTION')                                              NTRA1080
      LRUNS=0
      READ(KEYBD,1031) OPTEST                                           NTRA1090
 1031 FORMAT(1A8)                                                       NTRA1100
 8450 CONTINUE                                                          NTRA1110
      LSTART=1                                                          NTRA1120
      LAST=80                                                           NTRA1130
C                                                                       NTRA1140
      DO 8756 IOR=1,20                                                  NTRA1150
      IF(OPTION(IOR).EQ.OPTEST) GO TO 8758                              NTRA1160
 8756 CONTINUE                                                          NTRA1170
C                                                                       NTRA1180
      DO 8765 IS=1,15                                                   NTRA1190
      IF(OPTEST.EQ.ASELT(IS)) GO TO 720                                 NTRA1200
 8765 CONTINUE                                                          NTRA1210
C                                                                       NTRA1220
      WRITE(ITTY,1000)                                                  NTRA1230
1000  FORMAT(1H0,' ERROR - OPTION NCT FOUND - RENTER ')                 NTRA1240
      GO TO 8749                                                        NTRA1250
C                                                                       NTRA1260
C***********************************************************************NTRA1270
C                                                                       NTRA1280
C ********************                                                  NTRA1290
C *                  *                                                  NTRA1300
C * OPTION EXECUTIVE * - CONTROL IS PASSED FROM OPTION TEST             NTRA1310
C *                  *                                                  NTRA1320
C ********************                                                  NTRA1330
 8758 CONTINUE                                                          NTRA1340
C     IF OPTEST IS EQUAL TO:                                            NTRA1350
C        1 X - TRANSFER CONTROL TO EXECUTION REGION                     NTRA1360
C        2 IC - TRANSFER CONTROL TO EXECUTION REGION                    NTRA1370
C        3 OUTPUT - TRANSFER CONTROL TO OUTPUT ARRAY ASSEMBLER          NTRA1380
C             A) TABLE (SETUP END-OF-RUN OUTPUT)                        NTRA1390
C             B) TRACK (SETUP DURING RUN DATA COLLECTION)               NTRA1400
C             C) LA (LIST ARRAY VALUES)                                 NTRA1410
C             D) T+D (OUTPUT TIME AND DATE)                             NTRA1420
C             E) STD (STANDARD OUTPUT)                                  NTRA1430
C             F) DUMP (OUTPUT ALL VARIABLES)                            NTRA1440
C             G) SAMPLE (SETUP FOR REAL-TIME DATA COLLECTION)           NTRA1450
C        4 TERM - TRANSFER CONTROL TO TERMINAL REGION                   NTRA1460
C        5 ADCA - ALTER ADC ARRAY                                       NTRA1470
C        6 DACA - ALTER DAC ARRAY                                       NTRA1480
C        7 F - FLOATING POINT OPERATIONS                                NTRA1490
C        8 I - INTEGER OPERATIONS                                       NTRA1500
C        9 MES - SEND MESSAGE TO LINE PRINTER                           NTRA1510
C       10 TEST - EXECUTE TEST ROUTINE                                  NTRA1520
C       11 RE-STR - RESTARTS (READS IN NEW DATA)                        NTRA1530
C       12 RESET - LOADS OUTPUT NAME ARRAY WITH BLANKS                  NTRA1540
C       13 REMOVE - REMOVES NAMES FROM OPTION LIST                      NTRA1550
C       14 MULTI - SETS UP MULTI RUN LOOP & VARIABLES                   NTRA1560
C       15 XM - TRANFER CONTROL TO EXECUTION REGION FOR MULTI RUNS      NTRA1570
C       16 UOPTION - USER OWN OPTION SUBROUTINE                         NTRA1580
C                                                                       NTRA1590
      IF(OPTEST.EQ.NX) GO TO 8802                                       NTRA1600
      IF(OPTEST.EQ.NIC) GO TC 8802                                      NTRA1610
      IF(OPTEST.EQ.NXM) GO TO 8802                                      NTRA1620
      IF(OPTEST.EQ.NTERM) GC TO 8809                                    NTRA1630
      IF(OPTEST.EQ.RESET) GC TO 8230                                    NTRA1640
      IF(OPTEST.EQ.REMOVE) GO TO 8234                                   NTRA1650
```

```
      IF(OPTEST.EQ.NRESR) RETURN 1
C
C ***************************************************************************
C
      IF(OPTEST.NE.NADCA) GO TO 5000
C ##### --- ADC ROUTINE ---#####
      CALL ADCA(ADCNUM,NAMADC,IADC,SCALAC,ADCPLA,ITTY,KEYBD)
 5000 CONTINUE
      IF(OPTEST.NE.NII.AND.OPTEST.NE.NFF) GO TO 5010
C #####---ALTER OR READ DATA LIST ---#####
      CALL RDWRT(OPTEST)
 5010 CONTINUE
      IF(OPTEST.NE.NDACA) GO TO 5020
C #####---DAC ROUTINE ---#####
      CALL DACA (DACNUM,NAMDAC,IDAC,SCALDC,DACPLA,ITTY,KEYBD)
 5020 CONTINUE
      IF(OPTEST.NE.NMES) GO TO 5035
C #####--- MESSAGE ROUTINE ---#####
      CALL MESRTN(ITTY,KEYBD,RETURN,LPTR)
 5035 CONTINUE
      IF(OPTEST.NE.NMULT) GO TO 5040
C #####--- MULTI RUN ---#####
      CALL MULTRN (ITTY,LOCAT,LOOPN,VALMR,FINLMR,ICT,IRUNS)
 5040 CONTINUE
      IF(OPTEST.NE.NTESTP) GO TO 5050
C #####--- TEST OPTION ---#####
      CALL TESTP(KEYBD,ITTY,NCOM,ORNAME,IORDER,BVALUE,RSVAL,REALT)
 5050 CONTINUE
      IF(OPTEST.NE.NUOPT) GO TO 5070
C #####--- USER OPTION SUBROUTINE ---#####
      WRITE(ITTY,8764)
5070  CONTINUE
      GO TO 8749
C
C***************************************************************************
C
C **************************
C *                        *
C * OUTPUT ARRAY ASSEMBLER * - CALLED FROM THE OPTION TEST OR EXECUTIVE
C *                        *
C **************************
C
  720 WRITE(ITTY,700)
  700 FORMAT(1H ,'UNIT,MODE')
      CALL UNFORM(5,1)
      DO 705 IOU=1,3
      IF(UNNAM(IOU).EQ.NAMEA(1)) GO TO 710
  705 CONTINUE
      WRITE(ITTY,715)
  715 FORMAT(1H ,'FOR UNIT ENTER  L (LIN PT), T (TELE), B (BOTH)')
      GO TO 720
  710 DO 725 MODE=1,4
      IF(MODENA(MODE).EQ.NAMEA(2)) GO TO 730
  725 CONTINUE
      WRITE(ITTY,735)
  735 FORMAT(1H ,'FOR MODE ENTER A (ALL), S (SING.), M (MULTI),
     1 XEQ (EXECUTION)')
      GO TO 720
  730 CONTINUE
C
```

```
      IF(OPTEST.NE.NLA) GO TO 2005                                      NTRA2260
C #####--- ARRAY SET UP ---####                                         NTRA2270
      CALL ARAST                                                        NTRA2280
 2005 CONTINUE                                                          NTRA2290
      IF(OPTEST.NE.NTABLE) GO TO 2010                                   NTRA2300
C #####--- TABLE SET UP ---#####                                        NTRA2310
      CALL TABLES(ITTY,KEYBD)                                           NTRA2320
 2010 CONTINUE                                                          NTRA2330
      IF(OPTEST.NE.NTRACK) GO TO 2020                                   NTRA2340
C #####--- TRACK ROUTINE ---#####                                       NTRA2350
      CALL TRACKS(ITTY,KEYBD,DT)                                        NTRA2360
 2020 CONTINUE                                                          NTRA2370
      IF(OPTEST.NE.NSAMPL) GO TO 2030                                   NTRA2380
C #####--- REAL TIME SAMPLE SETUP SUBROUTINE ---#####                   NTRA2390
      WRITE(ITTY,8764)                                                  NTRA2400
 2030 CONTINUE                                                          NTRA2410
      IF(OPTEST.NE.NPLOT) GO TO 2040                                     PLOT
C #####--- PREPARE DATA FOR PLOTTING ---#####
      CALL PLOTS(ITTY,KEYBD)
 2040 CONTINUE
C #####--- SET UP OUTPUT NAME ARRAY ---#####                            NTRA2420
      IF(MODE.NE.2) GO TO 670                                           NTRA2430
      OUTNAM(21)=OPTEST                                                 NTRA2440
      DEVICE(21)=IOU                                                    NTRA2450
      GO TO 8253                                                        NTRA2460
  670 DO 741 JJ=1,20                                                    NTRA2470
      IF(OUTNAM(JJ).EQ.OPTEST) GO TO 740                                NTRA2480
  741 CONTINUE                                                          NTRA2490
      DO 745 JJ=1,20                                                    NTRA2500
      IF(OUTNAM(JJ).EQ.BLANK) GO TO 740                                 NTRA2510
  745 CONTINUE                                                          NTRA2520
  740 OUTNAM(JJ)=OPTEST                                                 NTRA2530
      IMODE(JJ)=MODE                                                    NTRA2540
      DEVICE(JJ)=IOU                                                    NTRA2550
      GO TO 8749                                                        NTRA2560
C #####--- REMOVE SINGLE VARIABLE ---#####                              NTRA2570
 8234 CONTINUE                                                          NTRA2580
      WRITE(ITTY,350)                                                   NTRA2590
  350 FORMAT(1H ,'WHAT')                                                NTRA2600
      READ(KEYBD,1031) OPTEST                                           NTRA2610
      DO 7350 I=1,20                                                    NTRA2620
      IF(OUTNAM(I).EQ.OPTEST) OUTNAM(I)=BLANK                           NTRA2630
 7350 CONTINUE                                                          NTRA2640
      GO TO 8749                                                        NTRA2650
C #####--- RESET OUTPUT NAME ARRAY ---#####                             NTRA2660
C                                                                       NTRA2670
C     LOAD OUTPUT NAME ARRAY WITH BLANKS                                NTRA2680
 8230 DO 8231 I=1,20                                                    NTRA2690
      OUTNAM(I)=BLANK                                                   NTRA2700
 8231 CONTINUE                                                          NTRA2710
      GO TO 8749                                                        NTRA2720
C***********************************************************************NTRA2730
C                                                                       NTRA2740
C ******************                                                    NTRA2750
C *                *                                                    NTRA2760
C * EXECUTION REGION * - CONTROL IS TRANSFERED FROM OPTION EXECUTIVE    NTRA2770
C *                *                                                    NTRA2780
C ******************                                                    NTRA2790
 8802 CONTINUE                                                          NTRA2800
C        1 FILL BVALUE ARRAY WITH INITIAL CONDITIONS                    NTRA2810
C        2 SET POTS                                                     NTRA2820
```

```
C        3 SET DACS
C        4 EQUIVALENCE + STORE IC
C        5 IF REAL TIME IS CALLED ENTER FLAGE
C        6 WRITE TIME,DATE, AND RUN NUMBER
C        7 CHANGE ANALOG MODE
C ************************************************************************
C
C####--- RUN COUNTER LOGIC ---#####
C
      IF(OPTEST.EQ.NIC) GO TO 170
      LRUNS=LRUNS+1
      ITRUNS=ITRUNS+1
  170 CONTINUE
C
C *                   *
C#####--- FIRST MULTI RUN VARIABLE INITIALIZATION PASS ---#####
C *                   *
C ******************
      IF(ICT.EQ.0.OR.OPTEST.NE.NXM) GO TO 165
      DO 160 I=1,ICT
      IF(LRUNS.LT.LOOPN(I)) GO TO 160
      KTEMP=LRUNS-LOOPN(I)
      BVALUE(LOCAT(I))=VALMR(I)+FLOAT(KTEMP)*FINLMR(I)
  160 CONTINUE
  165 CONTINUE
C
C #####--- USER INITIALIZATION SUBROUTINES
      RETURN 2
      ENTRY NTRAT1(*,*,*,*)
C ******************
C *                   *
C#####--- SECOND PASS FOR MULTI-RUN VARIABLE REINITIALIZATION ---#####
C *                   *
C ******************
      IF(ICT.EQ.0.OR.OPTEST.NE.NXM) GO TO 155
      DO 150 I=1,ICT
      IF(LRUNS.LT.LOOPN(I)) GO TO 150
      KTEMP=LRUNS-LOOPN(I)
      BVALUE(LOCAT(I))=VALMR(I)+FLOAT(KTEMP)*FINLMR(I)
  150 CONTINUE
  155 CONTINUE
C
C ************************************************************************
C
C     THIS ROUTINE SETS POTS ON 680
C
      IF(REALT.LT..5) GO TO 75
      DO 1702 I=1,120
      IF(IPOT(I).EQ.IPOTAD(I)) GO TO 1702
      CALL POTCHK(I,IPOT(I),3,&8152,&8152)
      IPOTAD(I)=IPOT(I)
 1702 CONTINUE
   75 CONTINUE
C
C     THIS CALL PLACES THE 680 IN IC
C
      CALL SAMO(6,ISAMOE)
      IKEEP = ISAMP - 1
      PASS = ASAMPL
      IDACK=0
      IADCK = 0
```

```
      JIN=0
      IF(OPTEST.EQ.NIC) GO TC 8749
C
      CALL WAITBU (200)
C
      IF(LRUNS.GT.1) GO TO 1888
      CALL TIMDAT(JDATE,ITTY)
      CALL TIMDAT(JDATE,LPTR)
C
      WRITE(LPTR,9050) ITRUNS
      WRITE(ITTY,9050) ITRUNS
 9050 FORMAT(1H0,'RUN ',I3,' HAS STARTED'/1H0,
     1 'OUTPUT BELOW')
 1888 CONTINUE
C
      CALL CLOCK(NTIME1)
C
C     *****     *****     *****     *****     *****     *****     *****
C
C#####--- ENTER REAL TIME PART ---#####
C *                   *
      IREALT = 0
      IF(REALT.GT..5) IREALT = 1
      IF(REALT.GT..5) IRT=1
C *                   *
C    AT THIS POINT THE RTMON SUBPROGRAM IS ACTIVATED
C    RTMON INTURN EXECUTS THE MODLE
C
C-----------------------------------------------------------------------
      RETURN3
      ENTRY NTRAT2(*,*,*,*)
C-----------------------------------------------------------------------
C    WHEN EXECUTION TAKES PLACE THE FOLLOWING TAKES PLACE:
C        1 REAL TIME PRECENT IS CALCULATED
C        2 CHANGE ANALOGE MODE
C        3 CALCULATE RUN MODE
C        4 EXECUTE SELECTED CUTPUTS FOR GIVEN MODE
C                B MODE=3 FOR MULTI-RUN
C                A MODE=1 FOR SINGLE RUN
C        5 IF MODE IS EQUAL TO TWO GO TO OPTION TEST
C        6 IF PROGRAM IS IN MULTI-RUN IRUNS IS GREATOR THAN LRUNS
C                A INCREMENT VARIABLES SELECTED
C                B EXECUTE NEXT RUN
C        7 END OF RUN LRUNS=0, IRUNS=1
C        8 RETURN TO OPTION TEST
C
C *******************
C
      CALL CLOCK(NTIME2)
      NRTIME=NTIME2-NTIME1
      IF(NRTIME.GT.1) RTPER= (TIME*10000.)/FLOAT(NRTIME)
      MODE=1
      IF(OPTEST.EQ.NXM) MODE=3
 8253 CONTINUE
C *******************
C *                   *
C * OUTPUT REGION     * - CONTROL IS TRANFERED FROM OPTION RUN EXECUTIVE
C *                   *
C *******************
      DO 8943 I=1,20
      IFR=1
```

```
      ILA=2                                                             NTRA4050
      IF(MODE.NE.2) GO TO 555                                           NTRA4060
      CNAME=OUTNAM(21)                                                  NTRA4070
      IF(DEVICE(21).EQ.1) ILA=1                                         NTRA4080
      IF(DEVICE(21).EQ.2) IFR=2                                         NTRA4090
      I=20                                                              NTRA4100
      GO TO 550                                                         NTRA4110
  555 IF(IMODE(I).EQ.4) GO TO 560                                       NTRA4120
      IF(IMODE(I).EQ.MODE) GO TO 560                                    NTRA4130
      GO TO 8943                                                        NTRA4140
  560 CNAME=OUTNAM(I)                                                   NTRA4150
      IF(CNAME.EQ.BLANK) GO TO 8943                                     NTRA4160
      IF(DEVICE(I).EQ.1) ILA=1                                          NTRA4170
      IF(DEVICE(I).EQ.2) IFR=2                                          NTRA4180
  550 CONTINUE                                                          NTRA4190
      DO 8946 K=IFR,ILA                                                 NTRA4200
      IF(K.EQ.1) MOPU=LPTR                                              NTRA4210
      IF(K.EQ.2) MOPU=ITTY                                              NTRA4220
      IF(CNAME.NE.NADCL) GO TO 3000                                     NTRA4230
C#####--- LIST ADC ARRAY ---#####                                       NTRA4240
      CALL LSTADC(ADCNUM,MOPU,IADC,SCALAC,NAMADC,ORNAME)                NTRA4250
      GO TO 8946                                                        NTRA4260
 3000 CONTINUE                                                          NTRA4270
      IF(CNAME.NE.NDACL) GO TO 3010                                     NTRA4280
C#####--- LIST DAC ARRAY ---#####                                       NTRA4290
      CALL LSTDAC(DACNUM,MOPU,IDAC,SCALDC,NAMDAC,ORNAME)                NTRA4300
      GO TO 8946                                                        NTRA4310
 3010 CONTINUE                                                          NTRA4320
      IF(CNAME.NE.NDUMP) GO TO 3020                                     NTRA4330
C#####--- DUMP ---#####                                                 NTRA4340
      CALL DUMP (MOPU,NCOM,IORDER,ORNAME,BVALUE)                        NTRA4350
      GO TO 8946                                                        NTRA4360
 3020 CONTINUE                                                          NTRA4370
      IF(CNAME.NE.NLA) GO TO 3030                                       NTRA4380
C#####--- LIST ARRAYS & VALUES ---#####                                 NTRA4390
      CALL ARAWT(MOPU,BVALUE,ORNAME)                                    NTRA4400
      GO TO 8946                                                        NTRA4410
 3030 CONTINUE                                                          NTRA4420
      IF(CNAME.NE.NNPC) GO TO 3040                                      NTRA4430
C#####--- SPECIAL PROGRAM END OF RUN DATA ---#####                      NTRA4440
      WRITE(ITTY,8764)                                                  NTRA4450
      GO TO 8946                                                        NTRA4460
 3040 CONTINUE                                                          NTRA4470
      IF(CNAME.NE.NPLOT) GO TO 3050                                     NTRA4480
C#####--- PLOTING SUBROUTINE ---#####                                   NTRA4490
      CALL PLOTS1
      CALL PLTOUT(XDOWN,YACROS,MOPU,NP,IPLF,JDATE,ORNAME)
      GO TO 8946                                                        NTRA4510
 3050 CONTINUE                                                          NTRA4520
      IF(CNAME.NE.NSTAT) GO TO 3060                                     NTRA4530
      WRITE(ITTY,8764)                                                  NTRA4540
      GO TO 8946                                                        NTRA4550
 3060 CONTINUE                                                          NTRA4560
      IF(CNAME.NE.NSTD) GO TO 3070                                      NTRA4570
C#####--- STANDARD OUTPUT SUBROUTINE ---#####                           NTRA4580
      CALL QSTD(MOPU)                                                   NTRA4590
      GO TO 8946                                                        NTRA4600
 3070 CONTINUE                                                          NTRA4610
      IF(CNAME.NE.NTABLE) GO TO 3080                                    NTRA4620
C#####--- TABLE OUTPUT ---#####                                         NTRA4630
      CALL TABLEO(MOPU,ORNAME,LRUNS,ITRUNS,BVALUE)                      NTRA4640
```

```
      GO TO 8946                                                        NTRA4650
 3080 CONTINUE                                                          NTRA4660
      IF(CNAME.NE.NTESTO) GO TO 3085                                    NTRA4670
C#####---TEST VALUE OUTPUT ---#####                                     NTRA4680
      WRITE(ITTY,8764)                                                  NTRA4690
      GO TO 8946                                                        NTRA4700
 3085 CONTINUE                                                          NTRA4710
      IF(CNAME.NE.NTIMD) GO TO 3090                                     NTRA4720
C#####---DATE---#####                                                  NTRA4730
      CALL TIMDAT(JDATE,MOPU)                                           NTRA4740
      GO TO 8946                                                        NTRA4750
 3090 CONTINUE                                                          NTRA4760
      IF(CNAME.NE.NTM) GO TO 3100                                       NTRA4770
C#####--- ERROR MONITOR OUTPUT ---#####                                  NTRA4780
      CALL ERMONT(MOPU,ORNAME,PHIMAX)                                   NTRA4790
      GO TO 8946                                                        NTRA4800
 3100 CONTINUE                                                          NTRA4810
      IF(CNAME.NE.NTRACK) GO TO 3110                                    NTRA4820
C#####--- TRACK OUTPUT ---#####                                         NTRA4830
      CALL TRACO(MOPU,ORNAME,DT)                                        NTRA4840
      GO TO 8946                                                        NTRA4850
 3110 CONTINUE                                                          NTRA4860
      IF(CNAME.NE.NUOT1) GO TO 3120                                     NTRA4870
C#####--- USER OUTPUT OPTION 1 ---#####                                  NTRA4880
      WRITE(ITTY,8764)                                                  NTRA4890
      GO TO 8946                                                        NTRA4900
3120  CONTINUE                                                          NTRA4910
 8946 CONTINUE                                                          NTRA4920
 8943 CONTINUE                                                          NTRA4930
 8764 FORMAT(1H0,'THIS OPTION HAS NOT BEEN PROGRAMED YET')              NTRA4940
      IF(MODE.EQ.2) GO TO 8749                                          NTRA4950
      IF(OPTEST.EQ.NX) GO TO 8152                                       NTRA4960
 8150 IF(IRUNS.EQ.LRUNS) GO TO 8152                                     NTRA4970
      GO TO 8802                                                        NTRA4980
 8152 CONTINUE                                                          NTRA4990
      LRUNS=0                                                           NTRA5000
      GO TO 8749                                                        NTRA5010
C                                                                       NTRA5020
C***********************************************************************NTRA5030
C                                                                       NTRA5040
C ******************                                                    NTRA5050
C *                *                                                    NTRA5060
C#####--- TERMINATE #####                                               NTRA5070
C *                *                                                    NTRA5080
C ******************                                                    NTRA5090
C8809 OSECB=0                                                           OVERLAY
 8809 CONTINUE
      CALL TIMDAT(JDATE,ITTY)                                           NTRA5110
      IF(IRT.NE.1) GO TO 5607                                           NTRA5120
C     CALL HPOST(DONECB,'DN')                                           OVERLAY
C     CALL WAITRT(OSECB)                                                OVERLAY
 5607 CONTINUE                                                          NTRA5150
      WRITE(ITTY,8821)                                                  NTRA5160
 8821 FORMAT(1H0,'PROGRAM TERMINATED')                                  NTRA5170
C     CALL RACN(1,IRACNE)                                               OVERLAY
C     CALL CHKIO                                                        OVERLAY
C     CALL WRTOFF                                                       OVERLAY
C     CALL RDOFF                                                        OVERLAY
      RETURN 4                                                          NTRA5220
      END                                                               NTRA5230
```

H-2.2 FUNCTION

Presented here are the Fortran listings for the FUNCTION subprograms called by the MODEL subprogram. The following list details the names and uses of the functions:

Function	Use
FF	Calculation of front wheel brake torque
FR	Calculation of rear wheel brake torque
FCSI	Calculation of the wheel slip sideforce shaping function
PTBAK	Calculation of a caster trail function
GETDEL	Calculation of a rectangular bump grid for VHTP No. 3
XINT	Linear interpolation of function values among input table data points
AMIN	Selection of the minimum value between two variables
POLY	Evaluation of a fifth-order polynomial approximation to a function

```
C     FUNCTION FF(P)
      FUNCTION FF(P)
C*********************************************************************
C     THIS FUNCTION CALCULATES THE FRONT WHEEL BRAKE TORQUE
C*********************************************************************
      COMMON/NEWTBS/TQBF(20),PBF(20),TQBR(20),PBR(20),
     1AFA(20),GAMF(20),NTF,NTR,NFA
      FF=XINT(P,PBF,TQBF,NTF)
      RETURN
      END
```

```
C     FUNCTION FR(P)
      FUNCTION FR(P)
C***********************************************************************
C     THIS FUNCTION CALCULATES THE REAR WHEEL BRAKE TORQUE
C***********************************************************************
      COMMON/NEWTBS/TQBF(20),PBF(20),TQBR(20),PBR(20),
     1AFA(20),GAMF(20),NTF,NTR,NFA
      FR=XINT(P,PBR,TQBR,NTR)
      RETURN
      END
```

```
C     FUNCTION FCSI(GAMI,SLPI)
      FUNCTION FCSI(GAMI,SLPI)
C***********************************************************************
C     THIS FUNCTION CALCULATES THE WHEEL-SLIP SIDE FORCE
C     SHAPING FUNCTION
C***********************************************************************
      COMMON/NEWTBS/TQBF(20),PBF(20),TQBR(20),PBR(20),
     1AFA(20),GAMF(20),NTF,NTR,NFA
      TMP=ABS(SLPI)
      FCSI = XINT(TMP,GAMF,AFA,NFA)
      RETURN
      END
```

```
C     SUBROUTINE PTBAK(BET,FRI,AKKI,PTBI)
      SUBROUTINE PTBAK(BET,FRI,AKKI,PTBI)
C***********************************************************************
C     THIS FUNCTION CALCULATES CASTER TRAIL
C***********************************************************************
      COMMON/PTBK/AP1,AP2,AP3,AP4,AP5,BTC1,BTC2
      AP5=600.
      AKKI=AP4+FRI/AP5
      TEMP=ABS(BET*57.29578)
      PTBI=AP1
      IF(TEMP.LE.BTC1)RETURN
      PTBI=AP3
      IF(TEMP.GT.BTC2)RETURN
      PTBI=AP1*(1.0-(TEMP-BTC1)*AP2)
      RETURN
      END
```

```
C     FUNCTION GETDEL(X,I,R5,NBMP)
      FUNCTION GETDEL(X,I,R5,NBMP)
C***********************************************************************
C     THIS SUBROUTINE PRODUCES THE BUMPS FOR VHTP #3
C***********************************************************************
      COMMON/XBS/XB(30),NS(4,30),DELX(4),XI(4),NNN
      COMMON/XYZ/NUMBR
      DIMENSION X(4)
      GETDEL=0.0
      DO 10 K=1,NBMP
      L=NBMP-K+1
      IF(X(I).LE.XB(L))NS(I,L)=NUMBR+NNN
      IF(X(I).GE.XB(L).AND.NUMBR.LE.NS(I,L))GO TO 20
   10 CONTINUE
      RETURN
   20 GETDEL=R5
      RETURN
      END
```

```
C     FUNCTION XINT(ARG,ARGTB,FUN,NP)
      FUNCTION XINT(ARG,ARGTB,FUN,NP)
C***********************************************************************
C     THIS FUNCTION PERFORMS LINEAR INTERPOLATION OF FUNCTION
C     VALUES BETWEEN INPUT TABLE DATA POINTS
C***********************************************************************
      DIMENSION ARGTB(NP),FUN(NP)
      DO 10 I=1,NP
      IF(ARG-ARGTB(I))30,20,10
   10 CONTINUE
      I=NP
   30 IF(I.EQ.1) I=2
      TEMP=(ARG-ARGTB(I-1))/(ARGTB(I)-ARGTB(I-1))
      XINT=FUN(I-1)+(FUN(I)-FUN(I-1))*TEMP
      RETURN
   20 XINT=FUN(I)
      RETURN
      END
```

```
C     FUNCTION AMIN(X,Y)
      FUNCTION AMIN(X,Y)
C***********************************************************************
C     THIS FUNCTION SELECTS THE MINIMUM VALUE BETWEEN TWO VARIABLES
C***********************************************************************
      IF(X-Y) 1,1,2
    1 AMIN=X
      RETURN
    2 AMIN=Y
      RETURN
      END
```

```
C     FUNCTION POLY(DL,TBL)
      FUNCTION POLY(DL,TBL)
C***********************************************************************
C     THIS FUNCTION EVALUATES A FIFTH-ORDED POLYNOMIAL
C     APPROXIMATION TO A FUNCTION
C***********************************************************************
      DIMENSION TBL(7)
      TMP=TBL(7)
      DO 10 I=1,6
      TMP=TMP*DL+TBL(7-I)
   10 CONTINUE
      POLY=TMP
      RETURN
      END
```

H-3. Analog Computer Diagrams

The analog computer diagrams are presented in this section.

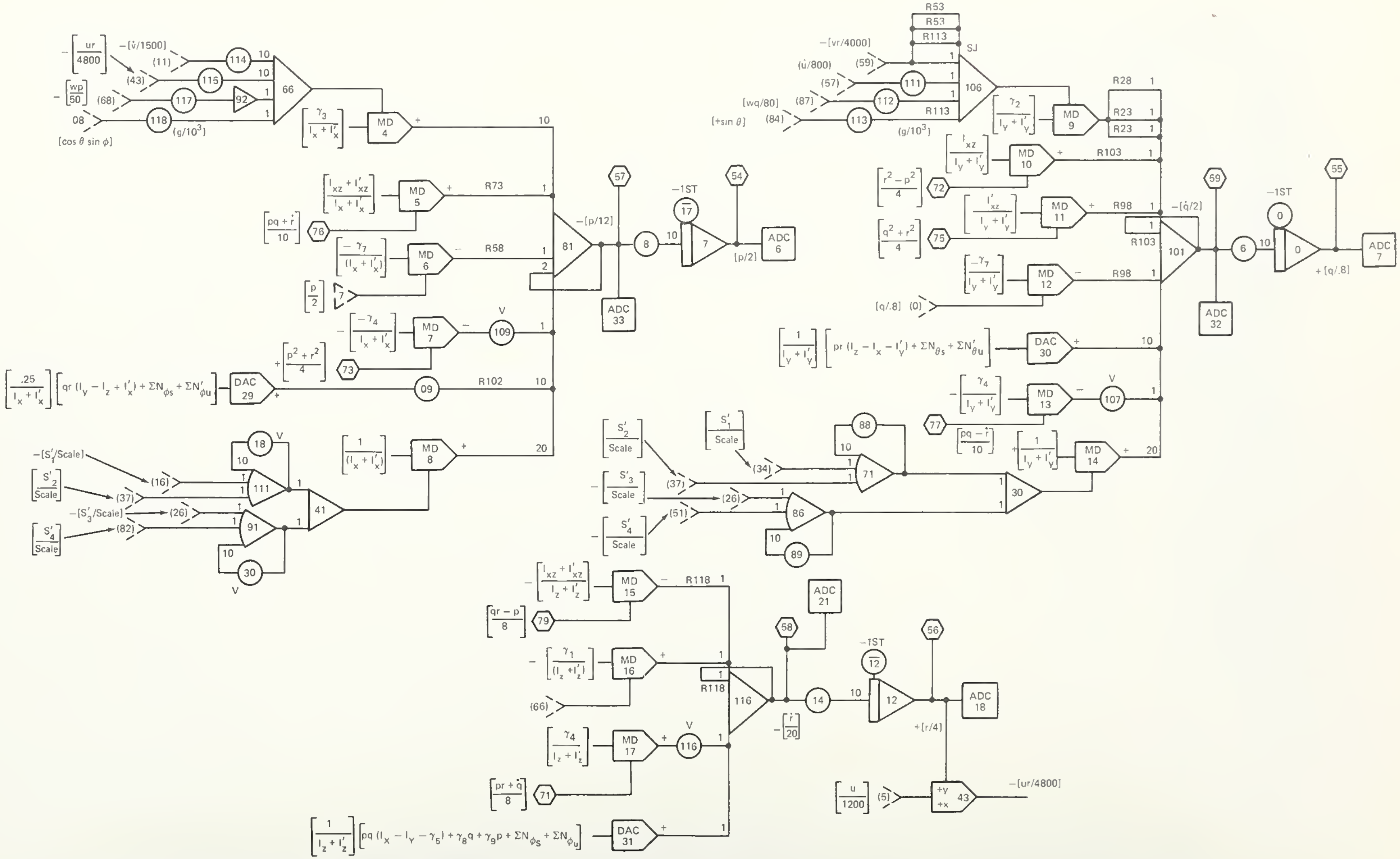


Fig. H-1 Analog Computer Diagram — Angular Accelerations and Velocities

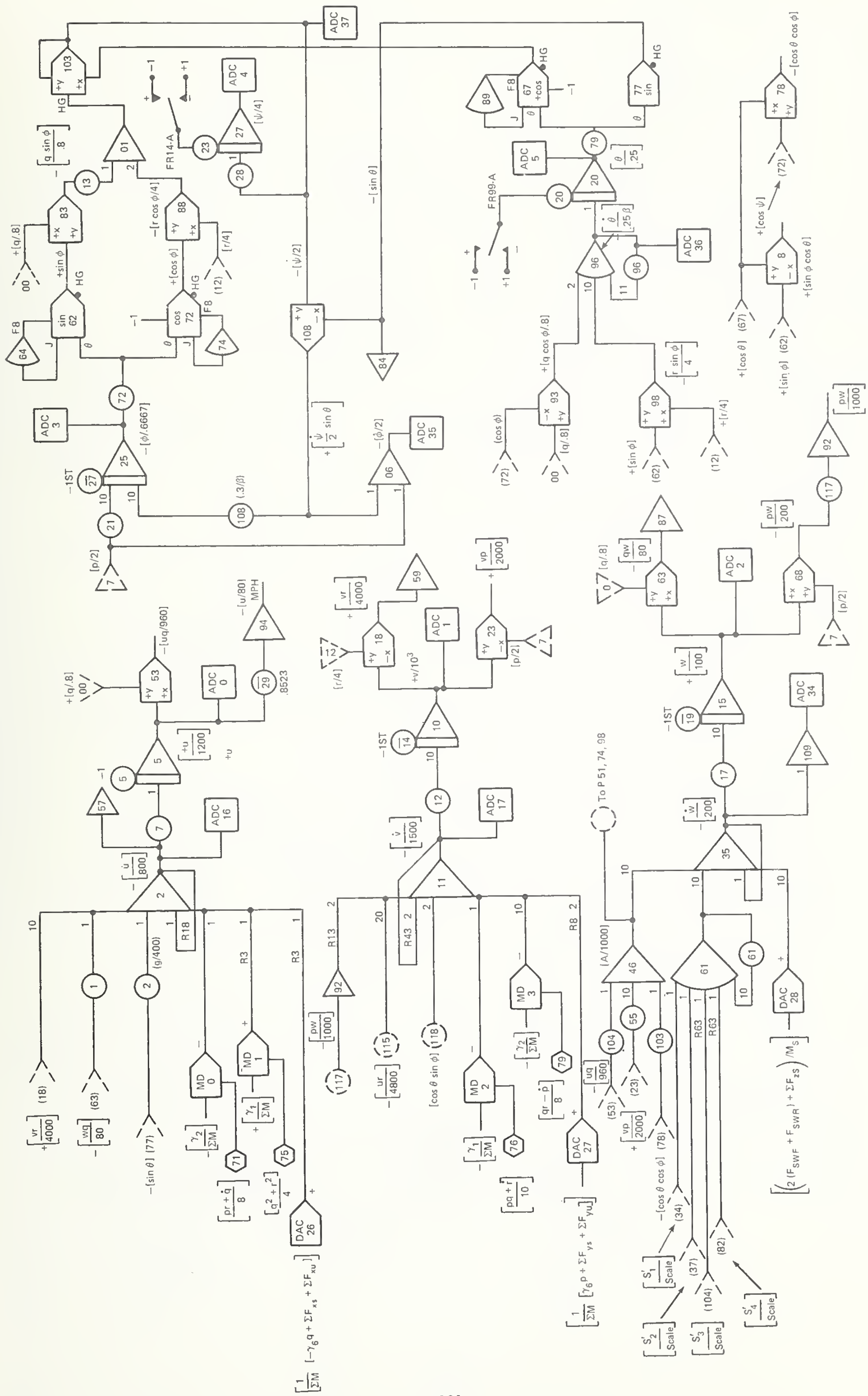


Fig. H-2 Analog Computer Diagram — Linear Accelerations and Velocities, Euler Angles

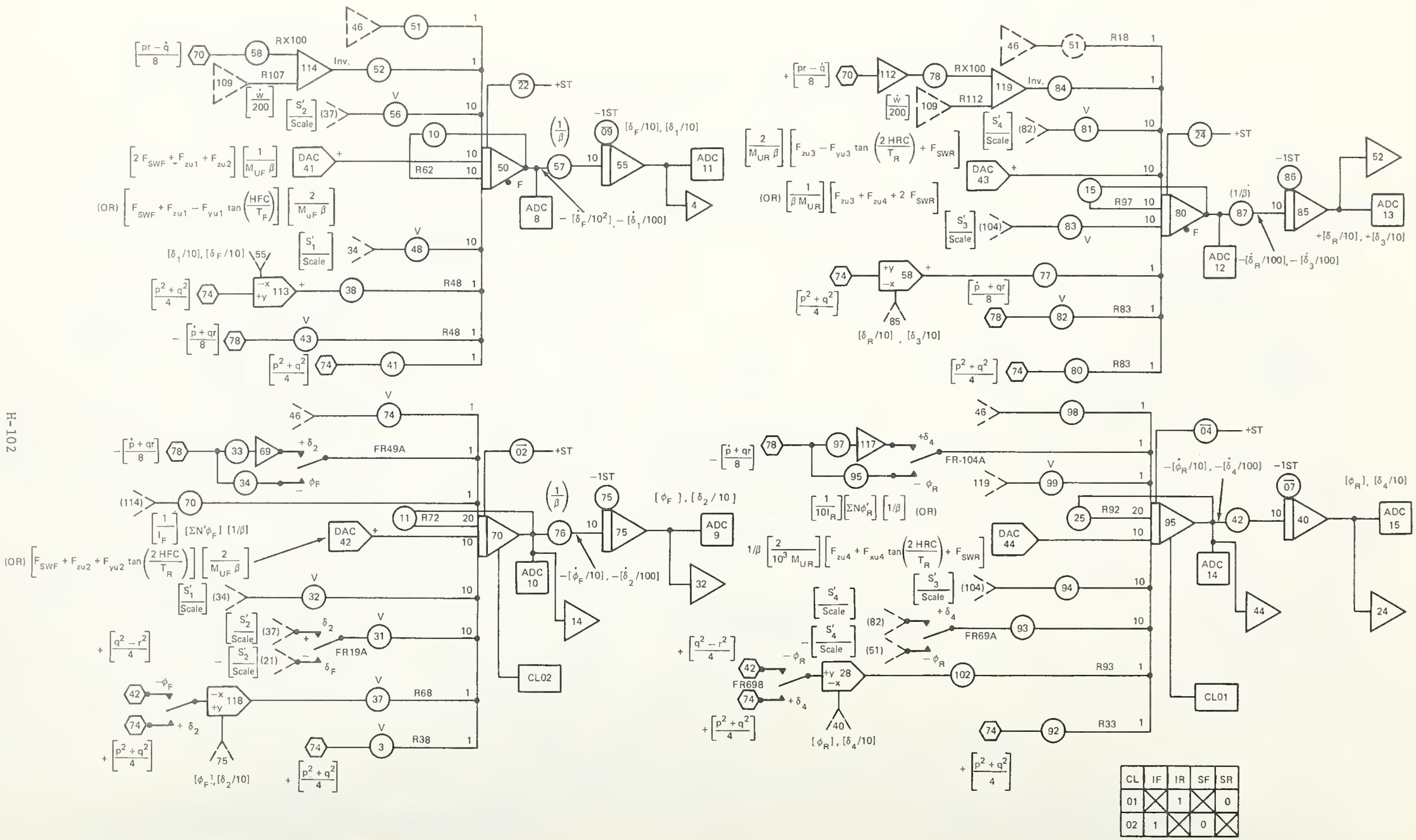


Fig. H-3 Analog Computer Diagram — Deflection Equations

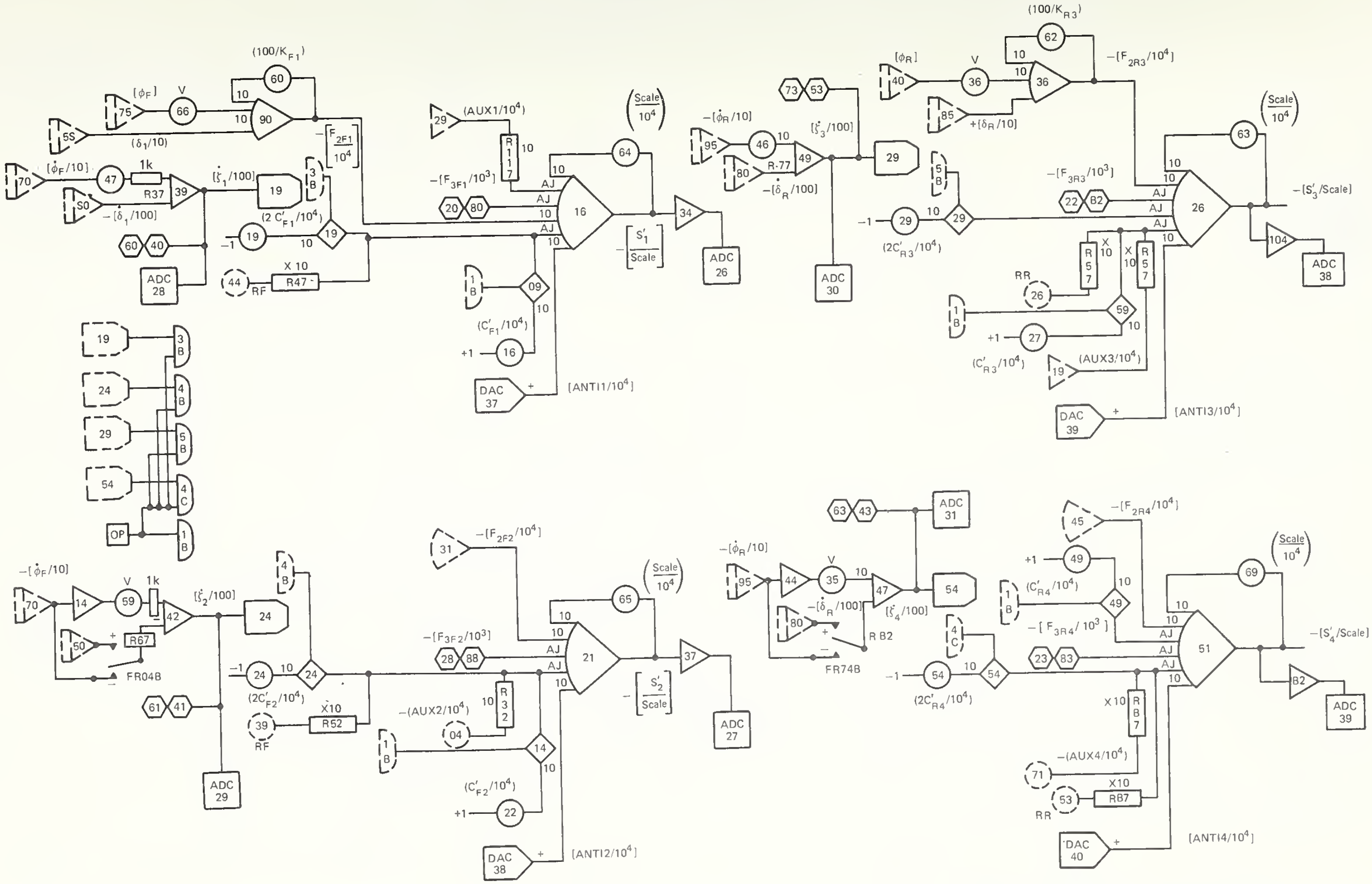
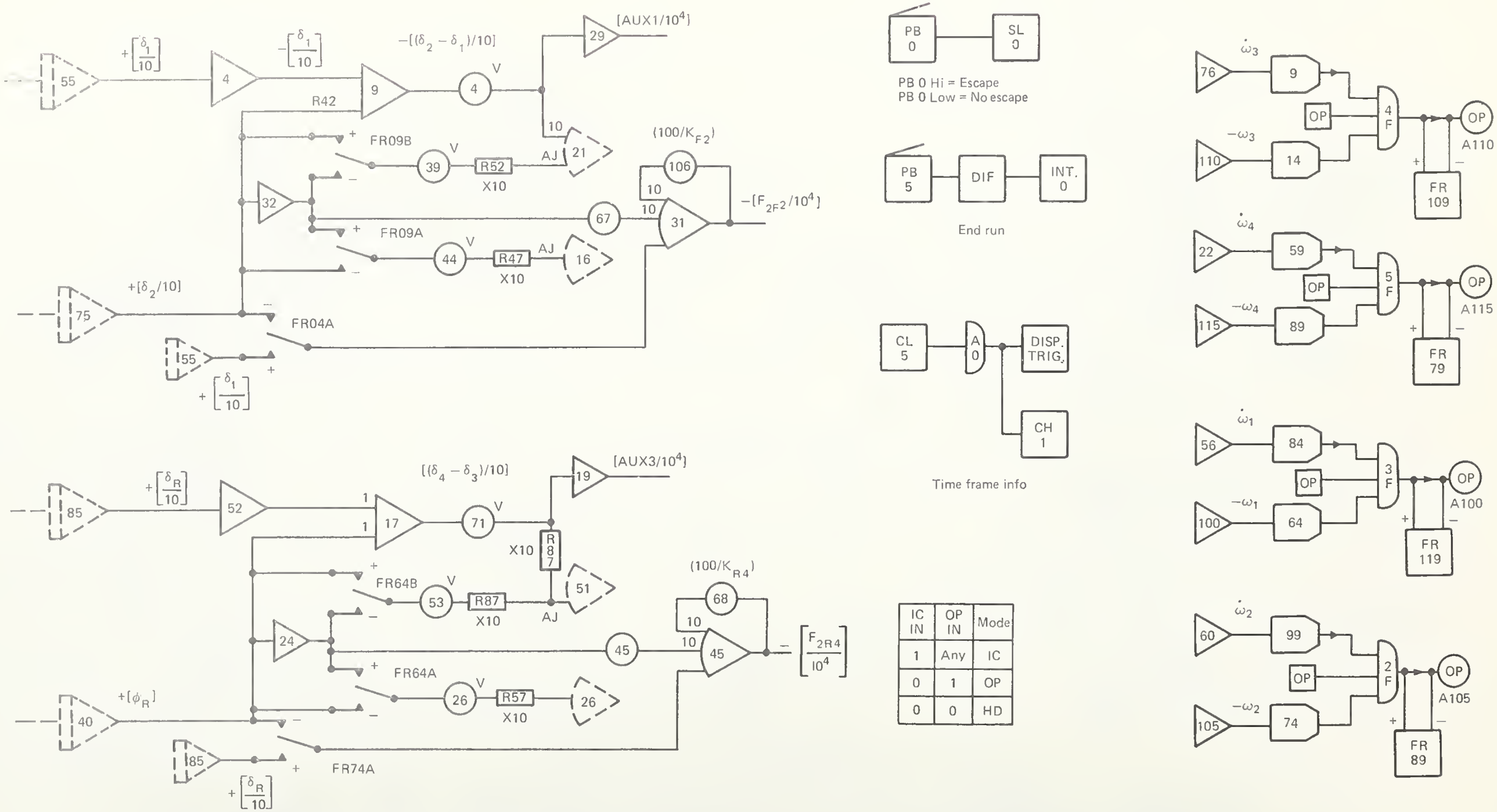


Fig. H-4 Analog Computer Diagram – Suspension Forces



IC IN	OP IN	Mode
1	Any	IC
0	1	OP
0	0	HD

Fig. H-5 Analog Computer Diagram — Auxiliary Roll Stiffness and Wheel-Slip Lockup Logic

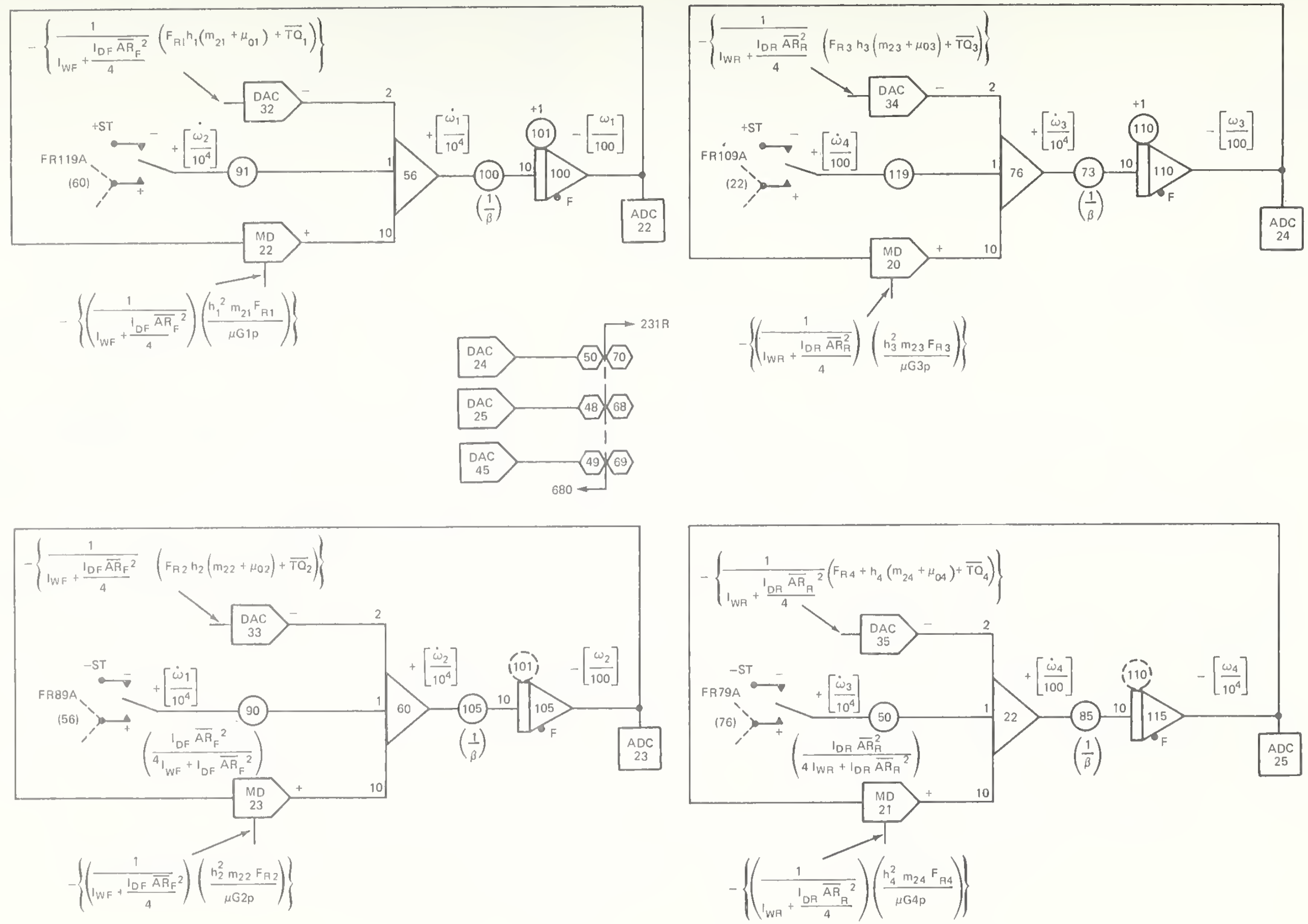


Fig. H-6 Analog Computer Diagram — Rotational Wheel Dynamics

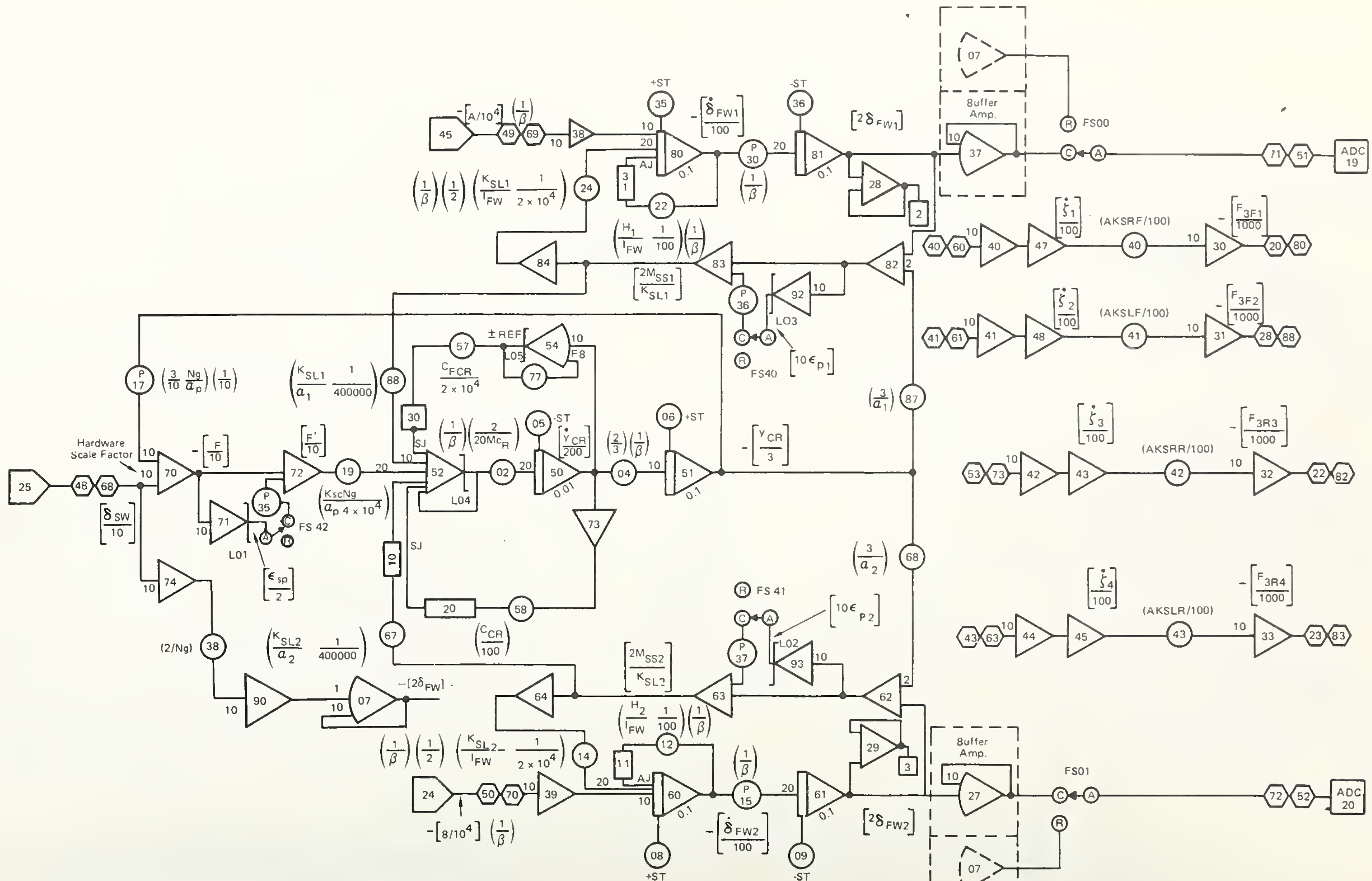


Fig. H-7 Analog Computer Diagram – Steering System and Shock Absorbers

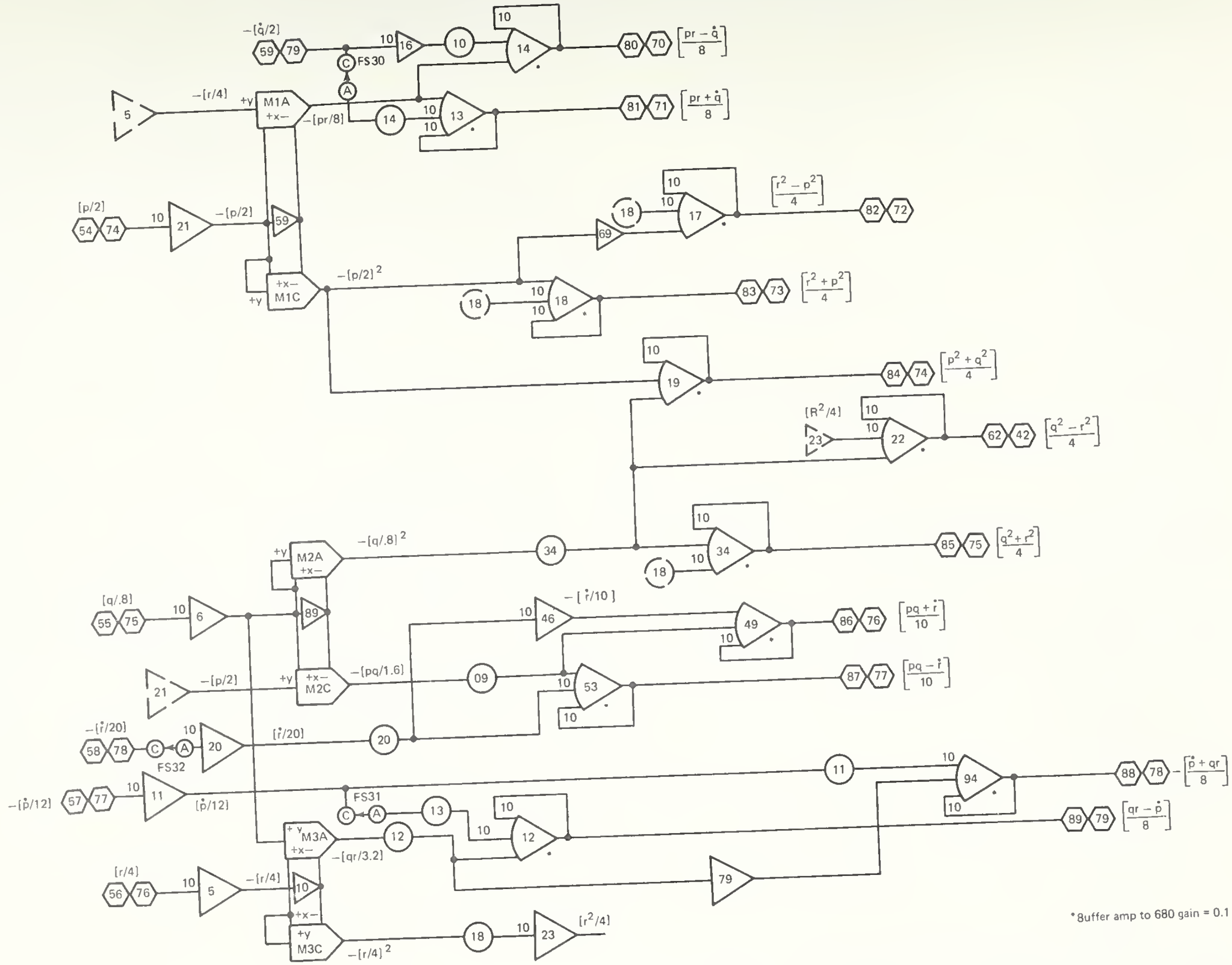


Fig. H-8 Analog Computer Diagram — Angular Accelerations and Velocities (higher order terms)

H-4. Program Parameter Symbols and Definitions

The symbols and definitions of the program parameters are presented in this section. The order of the parameters corresponds to the input data cards.

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS

IN ORDER BY DATA INPUT CARDS

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
001	MS	M_S	Total sprung mass (lb-s^2/in.)
002	MUF	M_{UF}	Total front unsprung mass (lb-s^2/in.)
003	MUR	M_{UR}	Total rear unsprung mass (lb-s^2/in.)
004	ZF	z_F	Static distance between center of gravity (c.g.) of sprung mass and spin axis of front wheels in z direction (in.)
005	ZR	z_R	Static distance between c.g. of sprung mass and spin axis of rear wheels in z direction (in.)
006	A	a	Distance between c.g. of sprung mass and spin axis of front wheels in x direction (in.)
007	B	b	Distance between c.g. of sprung mass and spin axis of rear wheels in x direction (in.)
008	TF	T_F	Front tread width (in.)
009	TR	T_R	Rear tread width (in.)
010	TSR	T_{SR}	Distance between solid rear axle spring centers in y direction (in.)
011	IX	I_X	Roll moment of inertia of sprung mass (lb-in.-s^2)
012	IY	I_Y	Pitch moment of inertia of sprung mass (lb-in.-s^2)
013	IZ	I_Z	Yaw moment of inertia of sprung mass (lb-in.-s^2)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS
IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
014	IXZ	I_{XZ}	Product of inertia of sprung mass (lb-in.-s^2)
015	IR	I_R	Moment of inertia of solid rear axle about a line through its c.g. and parallel to the x axis (exclude 0 for computational purposes) (lb-in.-s^2)
016	ROOR		Vehicle rollover angle (deg)
017	RF	R_F	Auxiliary roll stiffness in front suspension (lb-in./rad)
018	STOP		Terminal velocity for simulation shutoff (mph)
019	AKF1	K_{F1}	Right front suspension spring rate (lb/in.)
020	AKF2	K_{F2}	Left front suspension spring rate (lb/in.)
021	AKR3	K_{R3}	Right rear suspension spring rate (lb/in.)
022	AKR4	K_{R4}	Left rear suspension spring rate (lb/in.)
023	ALS		Brake antilock option: 023 = 0, no; 023 = 1, yes
024	RR	R_R	Auxiliary roll stiffness in rear suspension (lb-in./rad)
025	CF1P	C'_{F1}	Coulomb damping at right front wheel (lb)
026	CF2P	C'_{F2}	Coulomb damping at left front wheel (lb)
027	CR3P	C'_{R3}	Coulomb damping at right rear wheel (lb)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS
IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
028	CR4P	C'_{R4}	Coulomb damping at left rear wheel (lb)
029	ZBAS	Z_{BIAS}	Bias constant to vertically shift the vehicle c.g. position (in.)
030	KRS	K_{RS}	Roll steer coefficient of solid rear axle (rad/rad)
031	RW	R_w	Undeflected tire radius (in.)
032	SCAL		Suspension force scale factor
033	FOT	$A_{\Omega_{TF}}$	Proportionality factor defining limits of small-angle cornering and camber stiffness approximation, front wheels
034	A0	A_{0F}	Constant term in small-angle cornering stiffness function, front wheels (lb/rad)
035	A1	A_{1F}	Linear term coefficient in small-angle cornering stiffness function, front wheels (1/rad)
036	A2	A_{2F}	Quadratic term coefficient in small-angle cornering stiffness function, front wheels (lb)
037	A3	A_{3F}	Linear term coefficient in small-angle camber stiffness function, front wheels (1/rad)
038	A4	A_{4F}	Quadratic term coefficient in small-angle camber stiffness function, front wheels (lb)
039	TIR	T_{IR}	Distance in the y direction between the centers of inside tires for solid rear axle with dual tires (in.)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS

IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
040	TOR	T_{OR}	Distance in the y direction between the centers of outside tires for solid rear axle with dual tires (in.)
041	KSC	K_{SC}	Steering column-gear flexibility (lb-in./rad)
042	NG	N_G	Gear ratio of steering gear box
043	TSD		Combined sinusoidal-trapezoidal steer maneuver; start time of trapezoidal steer angle decrease (s)
044	DSLM		Combined sinusoidal-trapezoidal steer maneuver; time to achieve 0 trapezoidal steer angle (exclude 0 for computational purposes) (s)
045	TFT		Combined sinusoidal-trapezoidal steer maneuver; end time of trapezoidal steer maneuver (s)
046	DSW2		Sinusoidal steer amplitude (second half of period) (deg)
047	IFW	I_{FW}	Moment of inertia of front wheel about the kingpin axis (lb-in.-s^2)
048	IF	I_F	Moment of inertia of solid front axle about a line through its c.g. and parallel to the x axis (lb-in.-s^2)
049	IWF	I_{WF}	Moment of inertia of front wheel about its spin axis (lb-in.-s^2)
050	IWR	I_{WR}	Moment of inertia of rear wheel about its spin axis (lb-in.-s^2)
051	IDR	I_{DR}	Moment of inertia of rear drive line about its spin axis (lb-in.-s^2)
052	ARR	$\overline{AR}_R$	Rear wheel drive axle ratio

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS
IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
053	TSF	T_{SF}	Distance between solid front axle spring centers in y direction (in.)
054	KFS	K_{FS}	Roll steer coefficient of solid front axle (rad/rad)
055	PT	$\overline{PT}$	Front wheel caster trail (in.)
056	YSA1	Y_{SA1}	Distance between kingpin axis and wheel centerline, measured along wheel spin axis, right front (in.)
057	YSA2	Y_{SA2}	Distance between kingpin axis and wheel centerline, measured along wheel spin axis, left front (in.)
058	PHS1	ϕ_{SA01}	Right wheel kingpin inclination angle at equilibrium suspension position (rad)
059	PHS2	ϕ_{SA02}	Left wheel kingpin inclination angle at equilibrium suspension position (rad)
060	CTSW		Caster trail switch: 060 = 0, function; 1, constant
061	IDF	I_{DF}	Moment of inertia of front drive line about its spin axis (lb-in.-s^2)
062	ARF	$\overline{AR}_F$	Front wheel drive axle ratio
063-074			Initial conditions: $p,q,r,u,v,w,x,y,z,\Theta,\phi,\psi$. Note z_0 and Θ_0 are computed values at $t = 0$ and need not be specified.
075	DT		Integration step size (s)
076	TN		Maximum run time (s)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS
IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (units)
077-078	KTI	K_{Ti}	Tire spring rate, front wheels (lb/in.)
079-080	KTI	K_{Ti}	Tire spring rate, rear wheels (lb/in.)
081-084	RPSI	ω_i	Initial wheel rotation rates computed at t = 0 (rad/s)
085	B1	B_{1F}	Load term coefficient of lateral friction coefficient, front tire (1/lb)
086	B2	B_{2F}	Velocity term coefficient of lateral friction coefficient, front tire (1/mph)
087	B3	B_{3F}	Constant term of lateral friction coefficient, front tire (dimensionless)
088	B4	B_{4F}	Quadratic load term coefficient of lateral friction coefficient, front tire ($1/lb^2$)
089-091			Initial conditions: $\dot{\delta}_i$
092	DELF	δ_{FIN}	Static displacement change in front suspension due to vehicle load configuration (in.)
093	DELR	δ_{RIN}	Static displacement change in rear suspension due to vehicle load configuration (in.)
094-106			Initial conditions: δ_i, $\dot{\phi}_R$, ϕ_R, δ_{FWi}, μ_{Xi}, S'_i
107	PPRT		Parameter table, print control: 107 = 0, no print; = 1, print

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS
IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (units)
108	FREQ		Sinusoidal steer frequency (Hz)
109			Unassigned
110	TQMX	$TQ_{D_{MAX}}$	Maximum available drive torque (lb-in)
111	KTQ	K_{TQ}	Drive torque gain factor (lb-s)
112	VC	V_C	Commanded velocity (mph)
113	MTSW		Front wheel kingpin moment switch: 113 = 0, out; = 1, in
114	DSWM	δ_{SW}	Maximum steering wheel angle, except sinusoidal steer (deg)
115	TST		Initial time of steer, except sinusoidal steer (s)
116	DSLP		Time to achieve maximum steer angle, equivalent to steer rate, except sinusoidal steer (exclude 0 for computational purposes) (s)
117	CGAM		Initial time of brake application, except drastic brake and steer (s)
118	CS		Initial time of brake application, except drastic brake and steer (s)
119	TQR	$\overline{TQ}_{Bi}$	Rear wheel brake torque (lb-in.)
120	TQF	$\overline{TQ}_{Bi}$	Front wheel brake torque (lb-in.)
121	PFL		Applied brake pressure (psi)
122	TTD		Drive torque control (s)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS

IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
123	DSW1		Sinusoidal steer amplitude (first half of period) (deg)
124			Unassigned
125	ISW5		VHTP drastic steer-brake switch: 125 = 0, no braking; = 1, braking
126	SW15		VHTP sinusoidal steer switch: 126 = 0, disable; = 1, enable
127			Unassigned
128	VTPS		VHTP switch
129	VHTP		VHTP index
130	AMCR	M_{CR}	Mass of steering system connecting rod ($lb\text{-}s^2/in.$)
131	ESP	ϵ_{SP}	Free play in steering gear box (rad)
132	KSL1	K_{SL1}	Steering linkage flexibility, right front wheel (lb-in./rad)
133	KSL2	K_{SL2}	Steering linkage flexibility, left front wheel (lb-in./rad)
134-135	AAI	a_{Li}	Length of steering linkage arms (in.)
136	CCR	C_{CR}	Viscous damping coefficient of steering system connecting rod (lb-s/in.)
137	CFCR	C_{FCR}	Coulomb damping of steering system connecting rod (lb)
138	AP	a_P	Length of Pitman arm (in.)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS
IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
139-140	EPI	ε_{Pi}	Free play in steer of front wheel (rad)
141	AERO		Aerodynamic option: 141 = 0, no; = 1, yes
142	VYW	v_{yw}	Velocity of cross wind in space-fixed axes, measured at sprung mass c.g. (in./s)
143	OMXW	ω_{xw}	Angular wind velocity about X axis in space-fixed system (rad/s)
144	OMZW	ω_{zw}	Angular wind velocity about Z axis in space-fixed system (rad/s)
145	RHOA	ρ_a	Mass density of air (lb-s^2/in.^{4})
146	CYP	C_{y_p}	Aerodynamic stability derivative of lateral force coefficient with respect to roll velocity
147	CYR	C_{y_r}	Aerodynamic stability derivative of lateral force coefficient with respect to yaw velocity
148	CZAL	C_{z_α}	Aerodynamic stability derivative of normal force coefficient with respect to aerodynamic angle of attack
149	CZQ	C_{z_q}	Aerodynamic stability derivative of normal force coefficient with respect to pitch velocity
150	CLP	C_{ℓ_p}	Aerodynamic stability derivative of rolling moment coefficient with respect to roll velocity
151	CLR	C_{ℓ_r}	Aerodynamic stability derivative of rolling moment coefficient with respect to yaw velocity

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS

IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
152	CMAL	C_{m_α}	Aerodynamic stability derivative of pitching moment coefficient with respect to aerodynamic angle of attack
153	CMQ	C_{m_q}	Aerodynamic stability derivative of pitching moment coefficient with respect to pitch velocity
154	CNP	C_{n_p}	Aerodynamic stability derivative of yawing moment coefficient with respect to roll velocity
155	CNR	C_{n_r}	Aerodynamic stability derivative of yawing moment coefficient with respect to yaw velocity
156	SF	S_f	Projected frontal area of vehicle, including tires and underbody parts; characteristic area upon which aerodynamic force and moment coefficients are based (in.^{2})
157	VLEN	ℓ_v	Vehicle length; characteristic length upon which aerodynamic moment coefficients are based (in.)
158	REWV	R_{w_v}	Resultant wind velocity (in./s)
159-168			Unassigned
169	SNT	$(SN)_T$	Tire data surface skid number
170	SNSO	$(SN)_{SO}$	Simulated vehicle surface skid number
171	SNS1	$(SN)_{S1}$	Simulated vehicle surface skid number

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS

IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
172	SNSW		Skid patch switch: 172 = 0, side approach; = 1, front approach; = 2, disable
173	DIST		Initial distance between car and skid patch (in.)
174	PL		Skid patch length (in.)
175	TSCP		Computer time scale factor
176	SCSW		Suspension compensation switch: 176 = 0, disable; = 1, enable
177-181			Unassigned
182-185	SII	SI_i	Wheel slip ratio at which peak braking coefficient of friction occurs
186	SARF	K_{S1}	Right front shock absorber rate (lb-s/in.)
187	SALF	K_{S2}	Left front shock absorber rate (lb-s/in.)
188	SARR	K_{S3}	Right rear shock absorber rate (lb-s/in.)
189	SALR	K_{S4}	Left rear shock absorber rate (lb-s/in.)
190-191			Unassigned
192	MTQB		Brake force rate (exclude 0 for computational purposes) (psi/s)
193	DCSW		Driver control switch: 193 = 0, disable; = 1, enable
194	LDF		Lateral displacement feedback gain (deg/in.)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS

IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
195	LDRF		Lateral displacement rate feedback gain (deg/in./s)
196-197	EKI	$\Delta\psi_i$	Static front wheel toe bias angle (deg)
198	BMPL		Length of single road bump (in.)
199	BMPS		Distance between leading edges of consecutive rectangular road bumps (in.)
200	BMPH		Road bump height (in.)
201	XB		Initial distance from car to first bump (in.)
202	APF1	P_{BF1}	Front tire peak braking coefficient of friction, constant term (dimensionless)
203	APF2	P_{BF2}	Front tire peak braking coefficient of friction, linear term coefficient (1/lb)
204	APR1	P_{BR1}	Rear tire peak braking coefficient of friction, constant term (dimensionless)
205	APR2	P_{BR2}	Rear tire peak braking coefficient of friction, linear term coefficient (1/lb)
206	MUSF	μ_{SF}	Front tire sliding coefficient of friction
207	MUSR	μ_{SR}	Rear tire sliding coefficient of friction
208	BCON		μ' beta constant

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
209	FCSW		Tire sideforce friction coefficient switch: 209 = 0, polynomial function; = 1, tabular function
210	S1F	S_{1F}	Front tire linear coefficient of sliding friction (1/lb)
211	S1R	S_{1R}	Rear tire linear coefficient of sliding friction (1/lb)
212	KLR	K_{LR}	Rear lateral force compliance steer (rad/lb)
213	KOTF	K_{OTF}	Front overturning moment compliance camber (rad/lb-in.)
214	KOTR	K_{OTR}	Rear overturning moment compliance camber (rad/lb-in.)
215-218			Unassigned
219-220	FEEI	$\Delta\phi_i$	Front wheel camber bias angle (deg)
221-222	THEI	$\Delta\phi_i$	Front wheel caster bias angle (deg)
223	ALMC		Antilock module configuration; 223 = 1, two modules; = 2, one module; = 3, three modules; = 4, four modules
224-230			Unassigned
231-232	HI	H_i	Viscous damping derivative in front wheel (lb-in.-s/rad)
233	LAMD	λ_D	Drive torque distribution factor
234-235			Unassigned

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS
IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
236	PS01	ϕ_{S01}	Constant angle between the right wheel steering axis and the wheel plane (rad)
237	PS02	ϕ_{S02}	Constant angle between the left wheel steering axis and the wheel plane (rad)
238-241	BRI	λ_{Bi}	Brake torque multiplier for wheel i
242	KCF	K_{CF}	Front lateral force compliance camber coefficient (rad/lb)
243	KCR	K_{CR}	Rear lateral force compliance camber coefficient (rad/lb)
244	KSR	K_{SR}	Rear aligning torque compliance steer coefficient (rad/(lb-in.))
245	RB1	B_{1R}	Load term coefficient of lateral friction coefficient, rear tire (1/lb)
246	RB2	B_{2R}	Velocity term coefficient of lateral friction coefficient, rear tire (1/mph)
247	RB3	B_{3R}	Constant term of lateral friction coefficient, rear tire (dimensionless)
248	RB4	B_{4R}	Quadratic load term coefficient of lateral friction coefficient, rear tire ($1/lb^2$)
249	AFK1	A_{F1}	Aligning torque coefficient, front tire (in./lb)
250	AFK2	A_{F2}	Aligning torque coefficient, front tire (in./lb)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS
IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
251	AFK3	A_{F3}	Aligning torque coefficient, front tire (in./rad$^{1/2}$)
252	ARK1	A_{R1}	Aligning torque coefficient, rear tire (in./lb)
253	ARK2	A_{R2}	Aligning torque coefficient, rear tire (in./lb)
254	ARK3	A_{R3}	Aligning torque coefficient, rear tire (in./rad$^{1/2}$)
255	OFC0	O_{F0}	Overturning moment coefficient, front tire (lb-in.)
256	OFC1	O_{F1}	Overturning moment coefficient, front tire (in./lb)
257	OFC2	O_{F2}	Overturning moment coefficient, front tire (in./(lb-rad))
258	OFC3	O_{F3}	Overturning moment coefficient, front tire (in./rad)
259	ORC0	O_{R0}	Overturning moment coefficient, rear tire (lb-in.)
260	ORC1	O_{R1}	Overturning moment coefficient, rear tire (in./lb)
261	ORC2	O_{R2}	Overturning moment coefficient, rear tire (in./(lb-rad))
262	ORC3	O_{R3}	Overturning moment coefficient, rear tire (in./rad)
263	CP0F	P_{F0}	Antipitch coefficient, front suspension (dimensionless)
264	CP1F	P_{F1}	Antipitch coefficient, front suspension (1/in.)
265	CP2F	P_{F2}	Antipitch coefficient, front suspension (1/in.^{2})

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS
IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
266	CP0R	P_{R0}	Antipitch coefficient, rear suspension (dimensionless)
267	CP1R	P_{R1}	Antipitch coefficient, rear suspension (1/in.)
268	CP2R	P_{R2}	Antipitch coefficient, rear suspension (1/in.^{2})
269	CR0F	R_{F0}	Antiroll coefficient, front suspension (dimensionless)
270	CR1F	R_{F1}	Antiroll coefficient, front suspension (1/in.)
271	CR2F	R_{F2}	Antiroll coefficient, front suspension (1/in^2)
272	CR0R	R_{R0}	Antiroll coefficient, rear suspension (dimensionless)
273	CR1R	R_{R1}	Antiroll coefficient, rear suspension (1/in.)
274	CR2R	R_{R2}	Antiroll coefficient, rear suspension (1/in.^{2})
275	STSW		Steer input switch: 275 = 0, VHTP sinusoidal or trapezoidal steer; = 1, tabular function
276	MMSW		Model modification switch: 276 = 0, nominal; $\neq$ 0, nonnominal
277	BMPN		Number of bumps in bump grid
278	TQB0		Time of brake application in combined drastic brake and steer VHTP (s)
279	TQB1		Time of brake release in combined drastic brake and steer VHTP (s)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS

IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
280-283			Unassigned
284	HFC	h_{FC}	Distance between ground and static roll center of front independent suspension (set to 0 for solid front axle configuration) (in.)
285	HRC	h_{RC}	Distance between ground and static roll center of rear independent suspension (set to 0 for solid rear axle configuration) (in.)
286	DRSW		Drive wheel switch: 286 = 0, rear-wheel drive; = 1, four-wheel drive
287	AXLE		Suspension configuration: 287 = 0, solid front/rear; = 1, independent front/rear
288	DUAL		Rear dual tire option: 288 = 0, no duals; = 1, duals
289	TIRE		Number of vehicle tires: 289 = 4, single rear tires; = 6, dual rear tires; = 10, double dual rear tires
290	ROT	$A_{\Omega_{TR}}$	Proportionality factor defining limits of small-angle cornering and camber stiffness approximation, rear wheels
291	RA0	A_{0R}	Constant term in small-angle cornering stiffness function, rear wheels (lb/rad)
292	RA1	A_{1R}	Linear term coefficient in small-angle cornering stiffness function, rear wheels (1/rad)
293	RA2	A_{2R}	Quadratic term coefficient in small-angle cornering stiffness function, rear wheels (lb)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS
IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
294	RA3	A_{3R}	Linear term coefficient in small-angle camber stiffness function, rear wheels (1/rad)
295	RA4	A_{4R}	Quadratic term coefficient in small-angle camber stiffness function, rear wheels (lb)

H-5. Vehicle Descriptor or Tire Model Coefficient Symbols and Definitions

The symbols and definitions of the program parameters that are vehicle desciptors or tire model coefficients are presented in this subsection.

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS

VEHICLE DESCRIPTORS OR TIRE MODEL COEFFICIENTS

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
001	MS	M_S	Total sprung mass (lb-s^2/in.)
002	MUF	M_{UF}	Total front unsprung mass (lb-s^2/in.)
003	MUR	M_{UR}	Total rear unsprung mass (lb-s^2/in.)
004	ZF	z_F	Static distance between center of gravity (c.g.) of sprung mass and spin axis of front wheels in z direction (in.)
005	ZR	z_R	Static distance between c.g. of sprung mass and spin axis of rear wheels in z direction (in.)
006	A	a	Distance between c.g. of sprung mass and spin axis of front wheels in x direction (in.)
007	B	b	Distance between c.g. of sprung mass and spin axis of rear wheels in x direction (in.)
008	TF	T_F	Front tread width (in.)
009	TR	T_R	Rear tread width (in.)
010	TSR	T_{SR}	Distance between solid rear axle spring centers in y direction (in.)
011	IX	I_X	Roll moment of inertia of sprung mass (lb-in.-s^2)
012	IY	I_Y	Pitch moment of inertia of sprung mass (lb-in.-s^2)
013	IZ	I_Z	Yaw moment of inertia of sprung mass (lb-in.-s^2)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS

VEHICLE DESCRIPTORS OR TIRE MODEL COEFFICIENTS

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
014	IXZ	I_{XZ}	Product of inertia of sprung mass (lb-in.-s^2)
015	IR	I_R	Moment of inertia of solid rear axle about a line through its c.g. and parallel to the x axis (exclude 0 for computational purposes) (lb-in.-s^2)
017	RF	R_F	Auxiliary roll stiffness in front suspension (lb-in./rad)
019	AKF1	K_{F1}	Right front suspension spring rate (lb/in.)
020	AKF2	K_{F2}	Left front suspension spring rate (lb/in.)
021	AKR3	K_{R3}	Right rear suspension spring rate (lb/in.)
022	AKR4	K_{R4}	Left rear suspension spring rate (lb/in.)
024	RR	R_R	Auxiliary roll stiffness in rear suspension (lb-in./rad)
025	CF1P	C'_{F1}	Coulomb damping at right front wheel (lb)
026	CF2P	C'_{F2}	Coulomb damping at left front wheel (lb)
027	CR3P	C'_{R3}	Coulomb damping at right rear wheel (lb)
028	CR4P	C'_{R4}	Coulomb damping at left rear wheel (lb)
030	KRS	K_{RS}	Roll steer coefficient of solid rear axle (rad/rad)
031	RW	R_W	Undeflected tire radius (in.)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS
VEHICLE DESCRIPTORS OR TIRE MODEL COEFFICIENTS

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
033	FOT	$A_{\Omega_{TF}}$	Proportionality factor defining limits of small-angle cornering and camber stiffness approximation, front wheels
034	A0	A_{0F}	Constant term in small-angle cornering stiffness function, front wheels (lb/rad)
035	A1	A_{1F}	Linear term coefficient in small-angle cornering stiffness function, front wheels (1/rad)
036	A2	A_{2F}	Quadratic term coefficient in small-angle cornering stiffness function, front wheels (lb)
037	A3	A_{3F}	Linear term coefficient in small-angle camber stiffness function, front wheels (1/rad)
038	A4	A_{4F}	Quadratic term coefficient in small-angle camber stiffness function, front wheels (lb)
039	TIR	T_{IR}	Distance in the y direction between the centers of inside tires for solid rear axle with dual tires (in.)
040	TOR	T_{OR}	Distance in the y direction between the centers of outside tires for solid rear axle with dual tires (in.)
041	KSC	K_{SC}	Steering column-gear flexibility (lb-in./rad)
042	NG	N_G	Gear ratio of steering gear box
047	IFW	I_{FW}	Moment of inertia of front wheel about the kingpin axis (lb-in.-s^2)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS

VEHICLE DESCRIPTORS OR TIRE MODEL COEFFICIENTS

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (units)
048	IF	I_F	Moment of inertia of solid front axle about a line through its c.g. and parallel to the x axis (lb-in.-s^2)
049	IWF	I_{WF}	Moment of inertia of front wheel about its spin axis (lb-in.-s^2)
050	IWR	I_{WR}	Moment of inertia of rear wheel about its spin axis (lb-in.-s^2)
051	IDR	I_{DR}	Moment of inertia of rear drive line about its spin axis (lb-in.-s^2)
052	ARR	$\overline{AR}_R$	Rear wheel drive axle ratio
053	TSF	T_{SF}	Distance between solid front axle spring centers in y direction (in.)
054	KFS	K_{FS}	Roll steer coefficient of solid front axle (rad/rad)
055	PT	$\overline{PT}$	Front wheel caster trail (in.)
056	YSA1	Y_{SA1}	Distance between kingpin axis and wheel centerline, measured along wheel spin axis, right front (in.)
057	YSA2	Y_{SA2}	Distance between kingpin axis and wheel centerline, measured along wheel spin axis, left front (in.)
058	PHS1	ϕ_{SA01}	Right wheel kingpin inclination angle at equilibrium suspension position (rad)
059	PHS2	ϕ_{SA02}	Left wheel kingpin inclination angle at equilibrium suspension position (rad)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS
VEHICLE DESCRIPTORS OR TIRE MODEL COEFFICIENTS

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
061	IDF	I_{DFZ}	Moment of inertia of front drive line about its spin axis (lb-in.-s^2)
062	ARF	$\overline{AR}_F$	Front wheel drive axle ratio
077-078	KTI	K_{Ti}	Tire spring rate, front wheels (lb/in.)
079-080	KTI	K_{Ti}	Tire spring rate, rear wheels (lb/in.)
085	B1	B_{1F}	Load term coefficient of lateral friction coefficient, front tire (1/lb)
086	B2	B_{2F}	Velocity term coefficient of lateral friction coefficient, front tire (1/mph)
087	B3	B_{3F}	Constant term of lateral friction coefficient, front tire (dimensionless)
088	B4	B_{4F}	Quadratic load term coefficient of lateral friction coefficient, front tire (1/lb^2)
092	DELF	δ_{FIN}	Static displacement change in front suspension due to vehicle load configuration (in.)
093	DELR	δ_{RIN}	Static displacement change in rear suspension due to vehicle load configuration (in.)
130	AMCR	M_{CR}	Mass of steering system connecting rod (lb-s^2/in.)
131	ESP	ε_{SP}	Free play in steering gear box (rad)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS
VEHICLE DESCRIPTORS OR TIRE MODEL COEFFICIENTS

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
132	KSL1	K_{SL1}	Steering linkage flexibility, right front wheel (lb-in./rad)
133	KSL2	K_{SL2}	Steering linkage flexibility, left front wheel (lb-in./rad)
134-135	AAI	a_{Li}	Length of steering linkage arms (in.)
136	CCR	C_{CR}	Viscous damping coefficient of steering system connecting rod (lb-s/in.)
137	CFCR	C_{FCR}	Coulomb damping of steering system connecting rod (lb)
138	AP	a_P	Length of Pitman arm (in.)
139-140	EPI	ε_{Pi}	Free play in steer of front wheel (rad)
142	VYW	v_{yw}	Velocity of cross wind in space-fixed axes, measured at sprung mass c.g. (in./s)
143	OMXW	ω_{xw}	Angular wind velocity about X axis in space-fixed system (rad/s)
144	OMZW	ω_{zw}	Angular wind velocity about Z axis in space-fixed system (rad/s)
145	RHOA	ρ_a	Mass density of air ($lb\text{-}s^2/in.^4$)
146	CYP	C_{y_p}	Aerodynamic stability derivative of lateral force coefficient with respect to roll velocity
147	CYR	C_{y_r}	Aerodynamic stability derivative of lateral force coefficient with respect to yaw velocity

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS
VEHICLE DESCRIPTORS OR TIRE MODEL COEFFICIENTS

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (units)
148	CZAL	C_{z_α}	Aerodynamic stability derivative of normal force coefficient with respect to aerodynamic angle of attack
149	CZQ	C_{z_q}	Aerodynamic stability derivative of normal force coefficient with respect to pitch velocity
150	CLP	C_{ℓ_p}	Aerodynamic stability derivative of rolling moment coefficient with respect to roll velocity
151	CLR	C_{ℓ_r}	Aerodynamic stability derivative of rolling moment coefficient with respect to yaw velocity
152	CMAL	C_{m_α}	Aerodynamic stability derivative of pitching moment coefficient with respect to aerodynamic angle of attack
153	CMQ	C_{m_q}	Aerodynamic stability derivative of pitching moment coefficient with respect to pitch velocity
154	CNP	C_{n_p}	Aerodynamic stability derivative of yawing moment coefficient with respect to roll velocity
155	CNR	C_{n_r}	Aerodynamic stability derivative of yawing moment coefficient with respect to yaw velocity
156	SF	S_f	Projected frontal area of vehicle, including tires and underbody parts; characteristic area upon which aerodynamic force and moment coefficients are based (in.^{2})
157	VLEN	ℓ_v	Vehicle length; characteristic length upon which aerodynamic moment coefficients are based (in.)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS
VEHICLE DESCRIPTORS OR TIRE MODEL COEFFICIENTS

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (units)
158	REWV	R_{W_V}	Resultant wind velocity (in./s)
169	SNT	$(SN)_T$	Tire data surface skid number
170	SNSO	$(SN)_{SO}$	Simulated vehicle surface skid number
171	SNS1	$(SN)_{S1}$	Simulated vehicle surface skid number
182-185	SII	SI_i	Wheel slip ratio at which peak braking coefficient of friction occurs
186	SARF	K_{S1}	Right front shock absorber rate (lb-s/in.)
187	SALF	K_{S2}	Left front shock absorber rate (lb-s/in.)
188	SARR	K_{S3}	Right rear shock absorber rate (lb-s/in.)
189	SALR	K_{S4}	Left rear shock absorber rate (lb-s/in.)
196-197	EKI	$\Delta\psi_i$	Static front wheel toe bias angle (deg)
202	APF1	P_{BF1}	Front tire peak braking coefficient of friction, constant term (dimensionless)
203	APF2	P_{BF2}	Front tire peak braking coefficient of friction, linear term coefficient (1/lb)
204	APR1	P_{BR1}	Rear tire peak braking coefficient of friction, constant term (dimensionless)
205	APR2	P_{BR2}	Rear tire peak braking coefficient of friction, linear term coefficient (1/lb)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS
VEHICLE DESCRIPTORS OR TIRE MODEL COEFFICIENTS

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
206	MUSF	μ_{SF}	Front tire sliding coefficient of friction
207	MUSR	μ_{SR}	Rear tire sliding coefficient of friction
210	S1F	S_{1F}	Front tire linear coefficient of sliding friction (1/lb)
211	S1R	S_{1R}	Rear tire linear coefficient of sliding friction (1/lb)
212	KLR	K_{LR}	Rear lateral force compliance steer (rad/lb)
213	KOTF	K_{OTF}	Front overturning moment compliance camber (rad/lb-in.)
214	KOTR	K_{OTR}	Rear overturning moment compliance camber (rad/lb-in.)
219-220	FEEI	$\Delta\phi_i$	Front wheel camber bias angle (deg)
221-222	THEI	$\Delta\theta_i$	Front wheel caster bias angle (deg)
231-232	HI	H_i	Viscous damping derivative in front wheel (lb-in.-s/rad)
236	PSO1	ϕ_{SO1}	Constant angle between the right wheel steering axis and the wheel plane (rad)
237	PSO2	ϕ_{SO2}	Constant angle between the left wheel steering axis and the wheel plane (rad)
242	KCF	K_{CF}	Front lateral force compliance camber coefficient (rad/lb)
243	KCR	K_{CR}	Rear lateral force compliance camber coefficient (rad/lb)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS
VEHICLE DESCRIPTORS OR TIRE MODEL COEFFICIENTS

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
244	KSR	K_{SR}	Rear aligning torque compliance steer coefficient (rad/(lb-in.))
245	RB1	B_{1R}	Load term coefficient of lateral friction coefficient, rear tire (1/lb)
246	RB2	B_{2R}	Velocity term coefficient of lateral friction coefficient, rear tire (1/mph)
247	RB3	B_{3R}	Constant term of lateral friction coefficient, rear tire (dimensionless)
248	RB4	B_{4R}	Quadratic load term coefficient of lateral friction coefficient, rear tire ($1/lb^2$)
249	AFK1	A_{F1}	Aligning torque coefficient, front tire (in./lb)
250	AFK2	A_{F2}	Aligning torque coefficient, front tire (in./lb)
251	AFK3	A_{F3}	Aligning torque coefficient, front tire ($in./rad^{1/2}$)
252	ARK1	A_{R1}	Aligning torque coefficient, rear tire (in./lb)
253	ARK2	A_{R2}	Aligning torque coefficient, rear tire (in./lb)
254	ARK3	A_{R3}	Aligning torque coefficient, rear tire ($in./rad^{1/2}$)
255	OFC0	O_{F0}	Overturning moment coefficient, front tire (lb-in.)
256	OFC1	O_{F1}	Overturning moment coefficient, front tire (in./lb)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS

VEHICLE DESCRIPTORS OR TIRE MODEL COEFFICIENTS

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
257	OFC2	O_{F2}	Overturning moment coefficient, front tire (in./(lb-rad))
258	OFC3	O_{F3}	Overturning moment coefficient, front tire (in./rad)
259	ORC0	O_{R0}	Overturning moment coefficient, rear tire (lb-in.)
260	ORC1	O_{R1}	Overturning moment coefficient, rear tire (in./lb)
261	ORC2	O_{R2}	Overturning moment coefficient, rear tire (in./(lb-rad))
262	ORC3	O_{R3}	Overturning moment coefficient, rear tire (in./rad)
263	CP0F	P_{F0}	Antipitch coefficient, front suspension (dimensionless)
264	CP1F	P_{F1}	Antipitch coefficient, front suspension (1/in.)
265	CP2F	P_{F2}	Antipitch coefficient, front suspension (1/in.^{2})
266	CP0R	P_{R0}	Antipitch coefficient, rear suspension (dimensionless)
267	CP1R	P_{R1}	Antipitch coefficient, rear suspension (1/in.)
268	CP2R	P_{R2}	Antipitch coefficient, rear suspension (1/in.^{2})
269	CR0F	R_{F0}	Antiroll coefficient, front suspension (dimensionless)
270	CR1F	R_{F1}	Antiroll coefficient, front suspension (1/in.)
271	CR2F	R_{F2}	Antiroll coefficient, front suspension (1/in^2)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS

VEHICLE DESCRIPTORS OR TIRE MODEL COEFFICIENTS

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
272	CR0R	R_{R0}	Antiroll coefficient, rear suspension (dimensionless)
273	CR1R	R_{R1}	Antiroll coefficient, rear suspension (1/in.)
274	CR2R	R_{R2}	Antiroll coefficient, rear suspension (1/in.^{2})
284	HFC	h_{FC}	Distance between ground and static roll center of front independent suspension (set to 0 for solid front axle configuration) (in.)
285	HRC	h_{RC}	Distance between ground and static roll center of rear independent suspension (set to 0 for solid rear axle configuration) (in.)
286	DRSW		Drive wheel switch: 286 = 0, rear-wheel drive; = 1, four-wheel drive
287	AXLE		Suspension configuration: 287 = 0, solid front/rear; = 1, independent front/rear
288	DUAL		Rear dual tire option: 288 = 0, no duals; = 1, duals
289	TIRE		Number of vehicle tires: 289 = 4, single rear tires; = 6, dual rear tires; = 10, double dual rear tires
290	ROT	$A_{\Omega_{TR}}$	Proportionality factor defining limits of small-angle cornering and camber stiffness approximation, rear wheels
291	RA0	A_{0R}	Constant term in small-angle cornering stiffness function, rear wheels (lb/rad)
292	RA1	A_{1R}	Linear term coefficient in small-angle cornering stiffness function, rear wheels (1/rad)

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
293	RA2	A_{2R}	Quadratic term coefficient in small-angle cornering stiffness function, rear wheels (lb)
294	RA3	A_{3R}	Linear term coefficient in small-angle camber stiffness function, rear wheels (1/rad)
295	RA4	A_{4R}	Quadratic term coefficient in small-angle camber stiffness function, rear wheels (lb)

*U.S. GOVERNMENT PRINTING OFFICE : 1979 0-632-032/47